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Installation Restoration Program: Hydrologic Measurements with an Estimated Hydrologic Budget for the Joliet Army Ammunition Plant, Joliet, Illinois

July 1991

Environmental Assessment and Information Sciences Division
Argonne National Laboratory, Argonne, Illinois 60439-4801

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by D.M. Diodato, H.E. Cho, and R.C. Sundell

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Hydrologic data were gathered from the 36.8-mi^2 Joliet Army Ammunition Plant (JAAP) located in Joliet, Illinois. Surface water levels were measured continuously, and groundwater levels were measured monthly. The resulting information was entered into a database that could be used as part of numerical flow model validation for the site. Deep sandstone aquifers supply much of the water in the JAAP region. These aquifers are successively overlain by confining shales and a dolomite aquifer of Silurian age. This last unit is unconformably overlain by Pleistocene glacial tills and outwash sand and gravel. Groundwater levels in the shallow glacial system fluctuate widely, with one well completed in an upland till fluctuating more than 17 ft during the study period. The response to groundwater recharge in the underlying Silurian dolomite is slower. In the upland recharge areas, increased groundwater levels were observed; in the lowland discharge areas, groundwater levels decreased during the study period. The decreases are postulated to be a lag effect related to a 1988 drought. These observations show that fluid flow at the JAAP is not steady-state, either on a monthly or an annual basis.

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Hydrologic budgets were estimated for the two principal surface water basins at the JAAP site. These basins account for 70% of the facility's total land area. Meteorological data collected at a nearby dam show that total measured precipitation was 31.45 in. and total calculated evapotranspiration was 23.09 in. for the study period. The change in surface water storage was assumed to be zero for the annual budget for each basin. The change in groundwater storage was calculated to be 0.12 in. for the Grant Creek basin and 0.26 in. for the Prairie Creek basin. Runoff was 7.02 in. and 7.51 in. for the Grant Creek and Prairie Creek basins, respectively. The underflow to the deep hydrogeologic system in the Grant Creek basin was calculated to be negligible. Sufficient data to calculate the underflow to the deep aquifer system in the Prairie Creek basin were unavailable. The errors in the hydrologic budget analysis could be reduced if more hydrologic measurements were made and on-site meteorological data were gathered.

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The authors wish to thank colleagues at Argonne National Laboratory for their help in this study. T. Filley and J. Schubert provided helpful contributions during the design and implementation phases, as well as insightful and productive comments on drafts of this document. In addition, the help of J. Schneider in coordinating site interfaces and of J. Mitchell in preparing the plates is greatly appreciated. T. Erdman of the Joliet Army Ammunition Plant facilitated many aspects of the field exercises. Discussions with Captain S. Bird and L. Nutter of the U.S. Army Toxic and Hazardous Materials Agency provided valuable guidance.

The coauthors of this report participated in the following manner: H. Cho and R. Sundell collected most of the data; H. Cho maintained the database, reduced stream stage data to a digital format, and assisted with the analyses; D. Diodato analyzed the data and prepared the manuscript.

INSTALLATION RESTORATION PROGRAM: HYDROLOGIC MEASUREMENTS WITH AN ESTIMATED HYDROLOGIC BUDGET FOR THE JOLIET ARMY AMMUNITION PLANT, JOLIET, ILLINOIS

by

D.M. Diodato, H.E. Cho, and R.C. Sundell

SUMMARY

The Joliet Army Ammunition Plant (JAAP), near Joliet, Illinois, historically produced ammunition for the U.S. Department of Defense. To support environmental restoration activities at the facility, water levels in groundwater and surface water systems were monitored from March 1990 through March 1991. A large amount of data was collected and stored in an electronic database. The data available in this database were used to estimate hydrologic budgets for two surface water basins on the site. The database, along with the hydrologic budget calculations, will serve as a platform to support fluid flow and contaminant transport modeling for the site.

Two principal surface water basins on the JAAP – the Grant Creek basin and the Prairie Creek basin – occupy approximately 70% of the land surface. These basins were outfitted with continuous stream-stage-monitoring equipment and staff gages. Monitoring of the Jordan and Jackson Creek basins, occupying the remaining land, was not included in the study proposal. Stream velocity profiling measurements were conducted for monitored stream reaches on several different dates in order to determine stream-stage-discharge relations. In addition, groundwater stage was measured in the Pleistocene water bearing units formed by the Wedron Till and the Henry Formation outwash, as well as in the Silurian dolomite. Measurements in 121 or more wells were taken monthly from March 1990 through March 1991. Some high-resolution deep well data from the deep Cambro-Ordovician system were available for the early part of the study. Other deep well data were gathered by JAAP personnel from the production wells on site. Precipitation data were acquired through the U.S. Army Corps of Engineers for the Brandon Road Dam, about seven miles north of JAAP.

For the hydrologic budget calculations, total precipitation of 31.45 in. and evapotranspiration of 23.09 in. were assumed to be distributed uniformly across the JAAP. Calculated runoff was 7.02 in. for the Grant Creek basin, and 7.51 in. for the Prairie Creek basin. The change in surface water storage was assumed to be zero for the annual budget for both basins. Change in groundwater storage was calculated for both the Pleistocene and Silurian systems for both basins. Calculations were based on changes in water levels averaged over all of the wells in the system and on representative gravity yields of 5% and 0.5% for the Pleistocene and Silurian systems, respectively. As a result, the total change in groundwater stage was 0.12 in. for the Grant Creek basin and 0.26 in. for the Prairie Creek basin. Fluctuations in water levels during the study period were large, with at least one well exhibiting more than 17 ft of variation.

The shallow groundwater systems at the site are controlled by topography, incised streams, and hydrogeologic conditions. The water levels in the shallow groundwater systems

vary both monthly and annually. This transient behavior of the shallow groundwater systems significantly affects the design and implementation of numerical models of the systems.

1 INTRODUCTION

The Joliet Army Ammunition Plant (JAAP) is located in Will County near Joliet, Illinois. Argonne National Laboratory (ANL) conducted an initial investigation of groundwater flow at the site in 1986 (Tsai et al. 1986). That investigation involved analysis of geologic and hydrogeologic conditions at the site, and subsequent numerical modeling of groundwater flow. Tsai et al. concluded that the success of the numerical model was greatly hampered by insufficient hydrologic data. This study, undertaken as a response to that conclusion, was designed to gather data describing water levels in the different hydrologic systems at JAAP. In addition, with the available data, estimated hydrologic budgets were calculated for the two principal surface water basins on the JAAP.

1.1 BACKGROUND

The site is divided into two main sections (Plate 1). In the Manufacturing Area (MAN) to the west of Illinois 53, explosive chemicals such as trinitrotoluene (TNT) were produced. East of the MAN and Illinois 53, the load-assemble-package (LAP) area was where munitions were loaded, assembled, and packaged for shipment. In response to concerns of contamination, the MAN was placed on the National Priorities List (NPL) in July 1987. Subsequently, in April 1989, the LAP was added to the NPL.

1.2 PURPOSE AND SCOPE

The purpose of this study is to provide the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) with a comprehensive hydrologic database and hydrologic budget estimates that will aid in accurate predictions of groundwater flow and contaminant transport and that will support remedial investigation/feasibility study (RI/FS) activities. As outlined in the work plan (Filley 1990), the scope encompasses monitoring of water levels in shallow and deep groundwater systems and in on-site surface water streams, as well collecting precipitation data from regional National Weather Service stations. Temperature data were also collected from these stations. The location of the water level monitoring points are shown in Plate 1.

1.3 TOPOGRAPHY, GEOLOGY, AND HYDROGEOLOGY

Tsai et al. (1986) describe the regional and local climatologic, geologic, and hydrogeologic conditions of the JAAP. Figure 1, a perspective view of the land surface, shows that the manufacturing area is located on topographically sloping ground, while the LAP side is relatively flat, except where the stream channel of Prairie Creek is incised. Plate 2 shows the topography of the region of the JAAP and water level monitoring points.

Figure 2 shows the stratigraphy and hydrostratigraphy at JAAP. It is based on Visocky et al. (1985) and the geologic log of deep well WSW-1 (ISWS 1941). The major confined aquifers occur, from bottom to top, in the St. Peter Sandstone and in the Silurian Dolomite. The water table aquifer occurs in the Pleistocene glacial sediments, which include the Wedron Till and the Henry Formation. The Henry Formation is sand and gravel outwash. The Maqouketa Shale acts

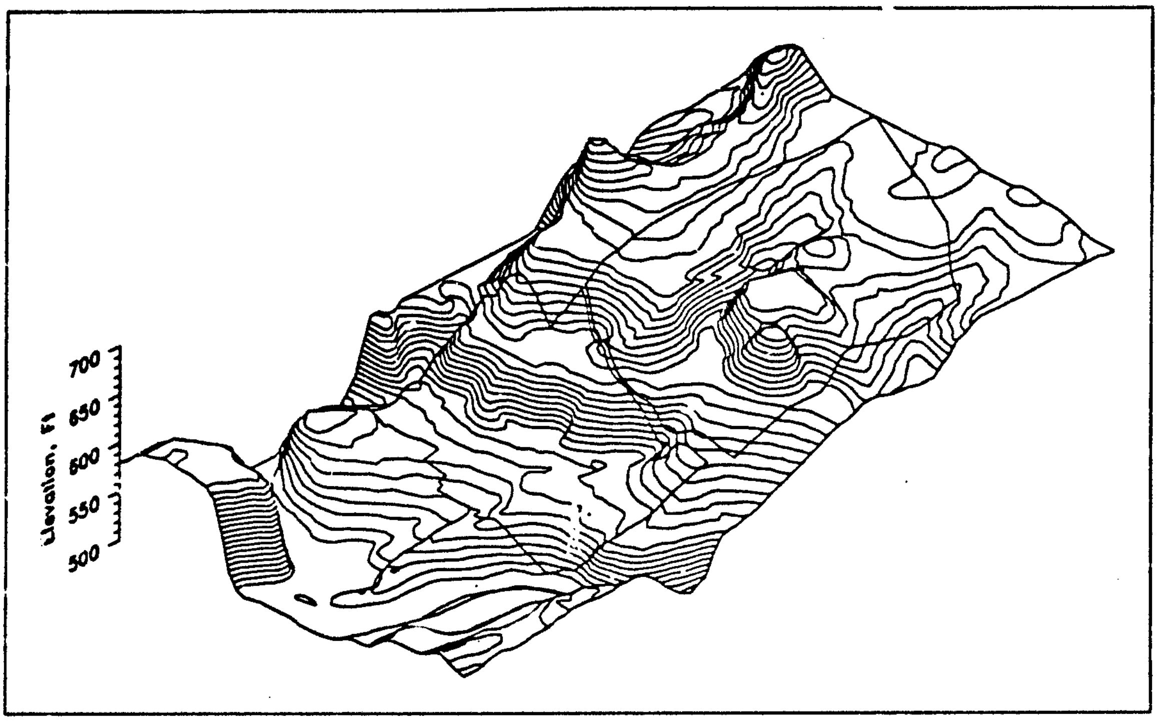

FIGURE 1 Perspective View of the Topography of the JAAP Region (Note that the MAN has steeper slopes and greater relief than the LAP. The contour interval is five feet. North is toward the top of the page, parallel to the short edge of the plot.)

as a confining unit (aquitard), separating the Silurian Dolomite and the St. Peter Sandstone. Note that the geologic sections from the Devonian through the Tertiary are missing at the JAAP.

1.4 SURFACE WATER BODIES AND HYDROLOGIC BASINS

Four principal streams exist at JAAP: Jackson, Grant, Jordan, and Prairie (Plate 1). Jackson Creek flows only across a short portion of the northern side of JAAP, while Jordan drains only a small portion of the southern side of the JAAP (Filley 1990). Some reaches of all of the streams have been modified by the U.S. Army Corps of Engineers. These modifications include riprapping some banks and straightening some reaches. The surface water divides defined by topography delineate the boundaries of the hydrologic basins defined by the four streams (Plate 2). The total area of the Grant Creek basin is 14.6 mi^2. The headwaters of Prairie Creek are off site. Within the map area shown on Plate 2, the Prairie Creek basin occupies 19.3 m^2. On site, the basins of Grant and Prairie creeks collectively occupy approximately 25.8 mi^2, or 70.1% of the 36.8-mi^2 facility (Chiu et al. 1990).

System	Series and Megagroup	Group and Formation	Hydrostratigraphic Units: Aquifer/Aquitard	Hydrostratigraphic Units: Log	Thickness (ft)	Description
Quaternary	Pleistocene	Undifferentiated	Pleistocene		10	Unconsolidated glacial deposits (pebbly clay [till], silt, and gravel); loess (windblown silt) and alluvial silts, sands, and gravels
Silurian	Niagaran	Port Byron Fm Racine Fm Waukesha Ls Joliet Ls	Silurian dolomite aquifer		126	Dolomite, silty at base, locally cherty
	Alexandrian	Kankakee Ls Edgewood Ls				
Ordovician	Cincinnatian	Maquoketa Shale Group	Maquoketa confining unit		127	Top 52': limestone and dolomite; bottom 75': shale with minor dolomite
	Mohawkian — Ottawa Ls Megagroup	Galena Group Decorah Subgroup Platteville Group	Galena-Platteville unit		350	Dolomite and/or limestone, cherty; dolomite, shale partings, speckled; dolomite and/or limestone, cherty, sandy at base
	Chazyan	Ancell Gr — St. Peter Ss	Ancell aquifer		167	Sandstone, fine and coarse grained; little dolomite; shale at top
	Canadian — Knox Megagroup	Prairie du Chien Group — Shakopee Dol	Middle confining unit — Prairie du Chien		65	Dolomite, sandy, cherty (oolitic), sands; sandstone, interbedded with dolomite; dolomite, white to pink, coarse grained
		New Richmond Ss			28	
		Oneota Dol			193	
Cambrian	St. Croixian	Jordan Ss	Eminence-Potosi		87	Dolomite, white, fine grained, geodic quartz, sandy at base
		Eminence Fm - Potosi Dol			160	
		Franconia Fm	Franconia		125	Dolomite, sandstone, and shale, glauconitic, green to red, micaceous
		Galesville Ss	Ironton-Galesville aquifer		155	Sandstone, fine to medium grained, well sorted
		Eau Claire Fm	Eau Claire		2 (bottom of hole)	Shale and siltstone; dolomite, glauconitic sandstone, dolomitic, glauconitic

FIGURE 2 Lithostratigraphy and Hydrostratigraphy of JAAP Deep Well WSW-1 (Source: Modified from Visocky et al. 1985; ISWS 1941)

2 DATA ACQUISITION

Water level measurements in groundwater wells were taken from March 1990 through March 1991. Additional data on production wells tapping deep aquifers were provided by site personnel. One groundwater well was equipped with a continuous-stage recorder, but it failed to produce continuous data because of technical difficulties. Surface water levels were recorded from staff gage readings, as well as by two continuous-stage recorders. Precipitation and temperature readings taken by the U.S. Army Corps of Engineers were acquired from the Hydraulic Master Database maintained by the Rock Island District of the U.S. Army Corps of Engineers. Table 1 is a summary of the type of data collected during the study.

2.1 GROUNDWATER LEVELS

Groundwater levels in wells on site were measured monthly with electric tape water-level probes. The temporal duration of measurements was minimized, with most monthly measurements completed within two days' time. In addition, the period of measurement was as regular as practicable, with most of the measurements conducted during the third week of each month.

TABLE 1 Hydrologic Data Collected for the JAAP

Month	Precipitation	Temperature	Surface Water Stage	Groundwater Level
Mar 90	x[a]	x	o[b]	x
Apr 90	x	x	o	x
May 90	x	x	x	x
Jun 90	x	x	x	x
Jul 90	x	x	x	x
Aug 90	x	x	x	x
Sep 90	x	x	x	x
Oct 90	x	x	x	x
Nov 90	x	x	x	
Dec 90	x	x	x	x
Jan 91	o[c]	o[c]	x[d]	x
Feb 91	x	o[c]	x	x
Mar 91	x	o[c]	x	x

[a]x indicates that data were collected.

[b]o indicates that data are missing.

[c]Data were not reported by monitoring station.

[d]The water in the streams and the stilling wells was frozen.

As reported by Filley (1990), 153 potential groundwater monitoring points on the JAAP were identified at the onset of this study. Of these, 100 are screened in shallow or intermediate groundwater systems. An additional 13 are screened in the deep Cambro-Ordovician system and are production wells for the site. Of the original 153 potential groundwater monitoring points, seven were never located in the field. In addition, 28 of the wells lack geologic logs, well logs, elevation data, or some combination of these three. Finally, an evaluation performed on the list of measured wells in June 1990 resulted in removing 25 wells from the monthly list.

This evaluation was based on the spatial proximity of wells tapping the same hydrogeologic unit. For example, if four wells were screened in the water table in close proximity to each other, as is the case near many of the tank farms, two of them were eliminated from the monthly measurement schedule. Eight of the wells that lacked some or all of the geologic, well, or elevation data were retained in the sampling schedule because the wells are located in regions sparsely populated by other "known" wells. It was assumed that descriptions of these eight wells will eventually become available, at which time the data will be of value.

As a result of all modifications to the list of potential groundwater monitoring points, 121 wells were measured monthly after June 1990. All wells for which spatial coordinates were available are shown in Plate 1, and available data on the spatial locations of all wells and their use in the groundwater level measurements are presented in Table A.1 of the Appendix. Table A.2 lists the geologic contacts encountered in the drilling of these wells, as reported in the well logs. Also shown in Table A.2 is the hydrostratigraphic unit in which the wells are screened, as inferred from the drillers' logs.

2.2 SURFACE WATER LEVELS

Because of the areal extent and coverage of the Grant and Prairie Creek basins, they were identified as desirable surface water level monitoring sites. Continuous-stage recorders were installed in these creeks where they cross Western Patrol Road. Recorder charts were changed monthly at the time of groundwater level measurements. A staff gage was installed on the LAP side where Prairie Creek flows onto the site. In this way, the off-site flow to Prairie Creek could be estimated. Because Grant Creek rises on site, it was not necessary to monitor its headwaters for the hydrologic budget calculations.

2.3 STREAM VELOCITY PROFILES AND STAGE-DISCHARGE RELATIONSHIPS

Given the stream stage, an empirical stage-discharge relation is commonly used to estimate stream flow. These stream stage-discharge relations are unique for each stream reach and must be individually determined. This is accomplished by measuring the velocity distribution across a stream in the vicinity of the stage recorder or staff gage. By measuring the velocity and the cross-sectional area of the stream, discharge can be calculated. Stream velocity profiles were measured for the three reaches of stream for which stage was measured. These were conducted at various times and for different stream stages throughout the study period.

2.4 DECONTAMINATION AND HEALTH AND SAFETY

To prevent possible cross-contamination from one groundwater well to another, the water level probes were rinsed at the start of each field day in a methanol bath and then rinsed in deionized water and wiped with a paper towel. Subsequently, after each water level reading was taken, the water level probes were rinsed in deionized water and wiped with a paper towel. Field personnel wore disposable surgical-type gloves, hard hats, and safety glasses to protect themselves from potential environmental hazards.

2.5 DATABASE MAINTENANCE

As the data were gathered, they were recorded on preprinted field data sheets. Subsequently they were entered into a spreadsheet to calculate static water elevations for all of the groundwater data points and to record stream stage levels at the three stream stage monitoring locations. Stream stage hydrographs from continuous recorders were digitized and entered into a spreadsheet. All of the data was subsequently imported from the spreadsheet into a database. Quality control was accomplished by checks of the database against original field data sheets. Graphical plots of the data aided in quality assurance because they helped to identify questionable data points, which were then checked.

3 RESULTS

A large volume of data was collected on groundwater and surface water levels in more than 100 groundwater wells and two surface streams. The data were collected on a monthly basis and were stored in an electronic database. These data values can be used as calibration targets to support numerical modeling of fluid flow at the JAAP. In addition to the data collection study, the available data were used to estimate hydrologic budgets for the Grant Creek and Prairie Creek surface water basins on the JAAP. The assumptions used in the hydrologic budget calculations are discussed in the following subsections. In addition, sources of error associated with the calculations are discussed in a separate subsection.

A hydrologic budget is an account of water movement into and out of a hydrologic basin. The hydrologic budget of a watershed can be calculated from the relation (Schicht and Walton 1961):

$$P = ET + R + \Delta S_s + \Delta S_g + U \tag{1}$$

where:

P = precipitation,

ET = evapotranspiration,

R = surface water runoff,

ΔS_s = change in surface water storage,

ΔS_g = change in groundwater storage, and

U = underflow.

Input occurs in the form of precipitation. Water exits the basin through a variety of means. Evapotranspiration is the process by which water evaporates into the atmosphere or is transpired by plants. It can occur from both surface water and groundwater reservoirs. In northern Illinois, evapotranspiration is generally at a maximum during the hotter summer months and approaches zero during the cold winter months of November through March (Schicht and Walton 1961). Runoff is water that exits the hydrologic system through surface streams. Surface water runoff in streams and creeks results from overland runoff and discharges from groundwater. Changes in storage can occur in both the surface water and groundwater reservoirs. For example, if the water level rose in Kemery Lake (Plate 1) over a given period, that rise would be an increase in surface water storage. Similarly, groundwater storage increases or decreases if water-table aquifers rise or fall, respectively. In this formulation, underflow is water that exits the hydrologic basin, either as leakage to deeper hydrologic systems or as discharge to surface streams below monitoring points.

3.1 PRECIPITATION

Precipitation data for three recording stations in the region are reported in Table 2. The average annual precipitation for north-central Illinois is approximately 33.5 in. of water, as interpreted from records for 1901 through 1940 (Visocky et al. 1985). Two out of three of the recording stations reported precipitation above the annual average for the period from March 1990 through February 1991. (This is a nonstandard measurement period as compared to the standard water year, which runs from October 1 through September 30.) This analysis used data from the Brandon Road Dam station, located near Joliet, Illinois, on the Des Plaines River. Located 7.5 miles north of the northern boundary of the LAP, this station was the closest of the three regional monitoring stations. The same rainfall that occurred at the Brandon Road Dam was assumed to have occurred uniformly across the JAAP. Figure 3 shows the cumulative rainfall for the study period at the Brandon Road Dam station. The daily precipitation data are presented in Table A.3.

TABLE 2 Rainfall, in Inches, at Several Area Recording Stations[a]

Month	Brandon Road Dam	Dresden Road Dam	Lockport Lock and Dam	Average
Mar 90	3.25	3.25	3.10	3.20
Apr 90	1.19	1.46	1.79	1.48
May 90	4.42	3.12	4.14	3.89
Jun 90	3.64	5.36	3.21	4.07
Jul 90	2.59	3.95	6.31	5.64
Aug 90	5.06	6.10	4.74	5.30
Sep 90	0.72	1.04	1.20	0.99
Oct 90	4.37	2.98	3.96	3.77
Nov 90	4.41	5.27	6.60	5.43
Dec 90	1.17	1.30	2.71	1.73
Jan 91	Missing	Missing	Missing	-
Feb 91	0.63	0.96	0.60	0.73
Mar 91	Incomplete	Incomplete	Incomplete	-
Total Mar 90 to Feb 91	31.45	34.79	38.36	36.23
Deviation from Average	-2.05	1.29	4.86	2.73

[a]For comparison, average annual precipitation for the region is approximately 33.5 in.

Source: Hydraulic Master Database, U.S. Army Corps of Engineers, Rock Island District, On-line Search and Retrieval.

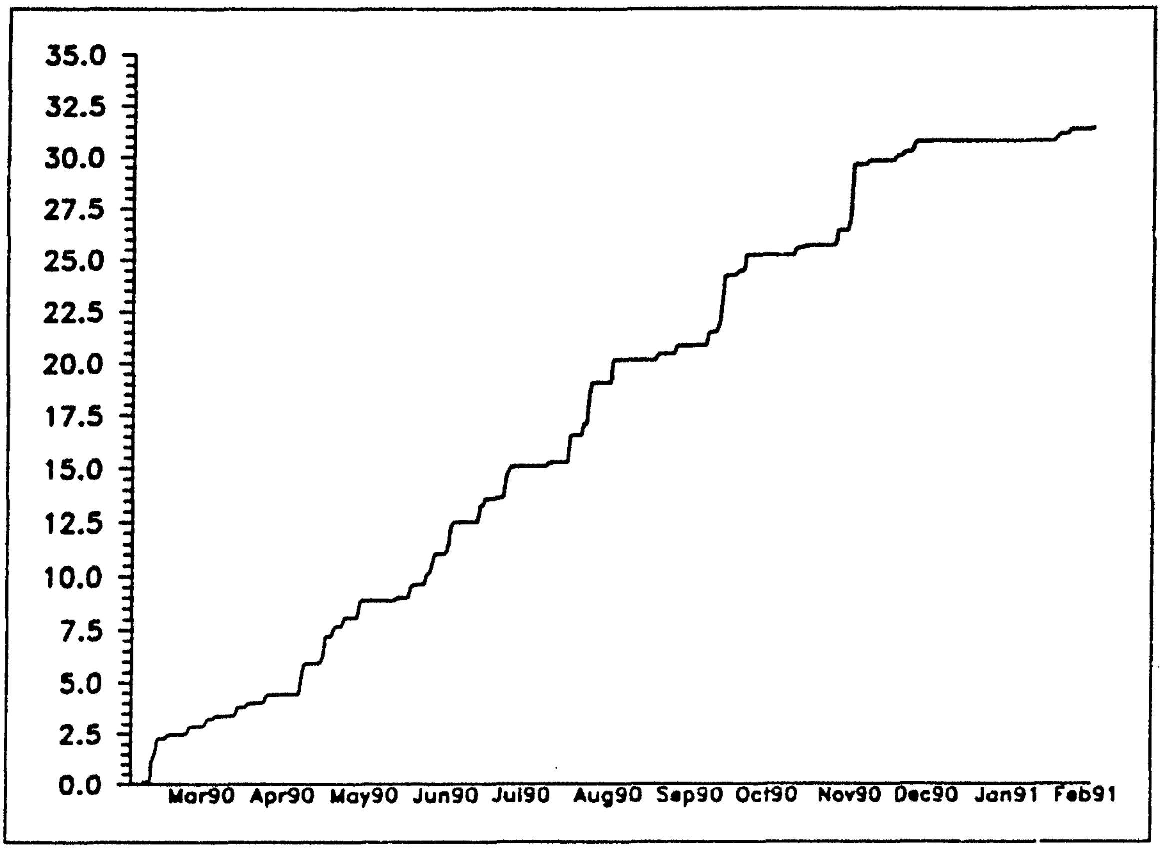

FIGURE 3 Cumulative Precipitation, in Inches, at Brandon Road Dam, near Joliet, Illinois, during the Study Period (Note the large rain event in November 1990, which caused regional flooding. January 1991 data are missing.)

3.2 EVAPOTRANSPIRATION

The Thornthwaite (1948) method was used to calculate evapotranspiration (ET) for the site during the study period. This method is an approach to calculating total potential evapotranspiration (PET) based on mean monthly temperature and hours of sun at a given latitude. It assumes that PET is zero for any month in which the mean monthly temperature is below freezing. Temperature data for the study period were collected from the U.S. Army Corps of Engineers Hydraulic Master Database for the Brandon Road Dam station. Data for January and February 1991 were not available. However, because the mean monthly temperature for these months in Illinois is routinely below zero, the absence of this data should not negatively affect the analyses. Table 3 shows the reported temperatures and the corresponding calculated PET. The total calculated PET for the Brandon Road Dam station was 23.09 in., or 73% of total precipitation. It was assumed that, like precipitation, PET applies uniformly across the JAAP site.

TABLE 3 Calculated Potential Evapotranspiration at the JAAP[a]

Month	Mean Temperature °F	°C	PET (cm)	Correction Factor@42N	Corrected PET (cm)	Corrected PET (in.)
Mar 90	37.83	3.24	1.50	1.03	1.55	0.61
Apr 90	43.93	6.63	3.17	1.12	3.55	1.40
May 90	50.90	10.50	5.13	1.26	6.46	2.54
Jun 90	63.71	17.62	8.81	1.27	11.18	4.40
Jul 90	65.89	18.83	9.44	1.28	12.08	4.76
Aug 90	64.50	18.06	9.04	1.19	10.75	4.23
Sep 90	59.07	15.04	7.46	1.04	7.76	3.06
Oct 90	46.22	7.90	3.81	0.95	3.62	1.43
Nov 90	39.85	4.36	2.05	0.82	1.68	0.66
Dec 90	25.38	-3.68	NA[b]	0.79	NA	NA
Jan 91	NA	NA	NA	0.82	NA	NA
Feb 91	NA	NA	NA	0.83	NA	NA
Total			50.41		58.64	23.09

[a]Calculation based on the Thornthwaite (1948) method using temperatures recorded at Brandon Road Dam.

[b]Not available.

Sources: Temperature data from Hydraulic Master Database, U.S. Army Corps of Engineers, Rock Island District, On-line Search and Retrieval.

In comparison, Schicht and Walton (1961) calculated ET for several small watersheds in northern Illinois in the 1950s. Their data showed that for a "cool, wet" year, the mean annual temperature was 49.6°F and that 24.71 in./yr of ET accounted for only 56% of 44.24 in./yr of precipitation. Alternatively, for a "hot, dry" year, the mean annual temperature was 53.5°F, and 25.76 in. of ET was 81% of 31.80 in. of precipitation. For a "warm, very dry" year, the mean annual temperature was 51.8°F, and 18.75 in./yr of ET was 96% of 19.49 in./yr of precipitation. Tsai et al. (1986) used a regional value of 27.00 in./yr of PET for the JAAP.

3.3 RUNOFF

Total annual runoff was calculated for both basins from measured stream stage data and the stream stage-discharge relationships derived from stream velocity profiling.

3.3.1 Stream Stage Hydrographs

Figures 4, 5, and 6 are the stream hydrographs from the continuous monitoring stations on Western Patrol Road and the hydrograph of the staff gage data from Prairie Creek at the

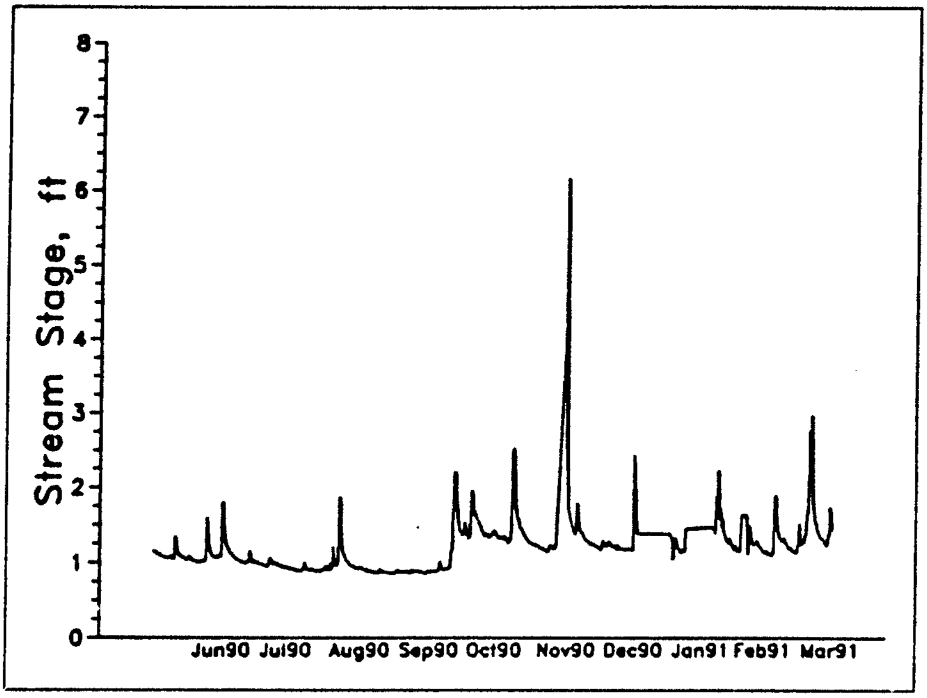

FIGURE 4 Hydrograph of Stream Stage of Grant Creek at Western Patrol Road

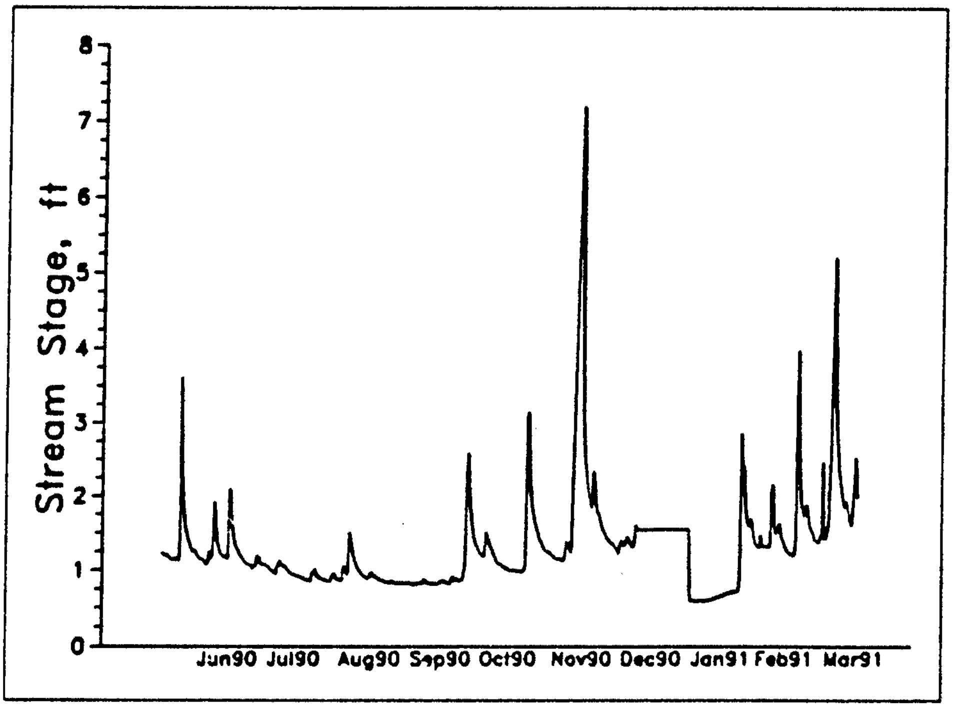

FIGURE 5 Hydrograph of Stream Stage of Prairie Creek at Western Patrol Road

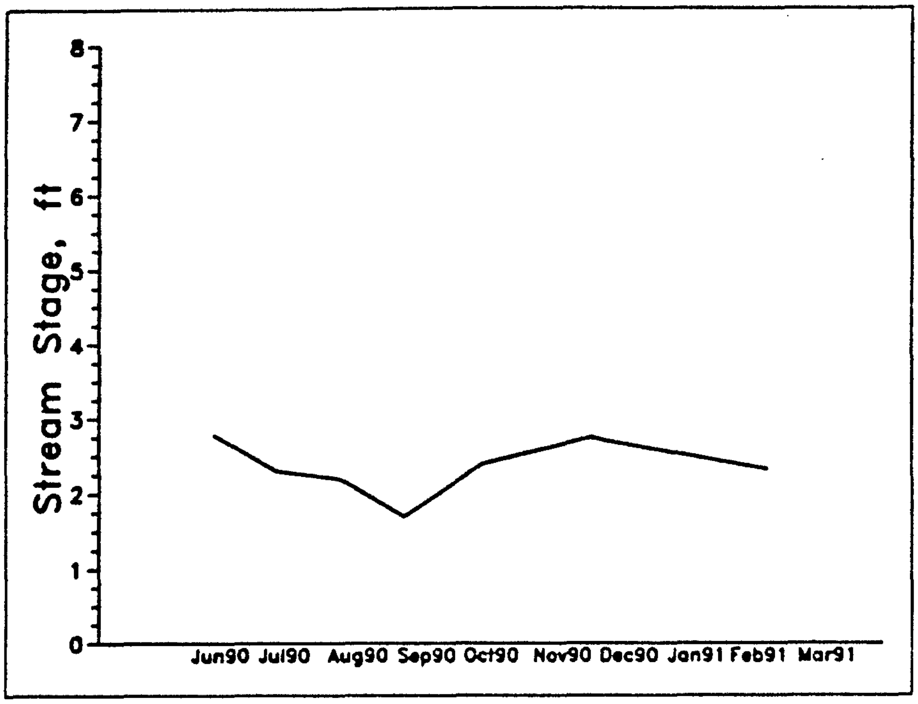

FIGURE 6 Hydrograph of Stream Stage of Prairie Creek at the Northern Boundary of LAP (Note that general seasonal trends are followed but that peaks and valleys are clipped by the low temporal resolution of the data.)

northeastern boundary of the LAP. Stream stage hydrographs from the continuous recorders were digitized at eight-hour intervals. The elevations of the stilling wells were such that the stages have a nonzero datum. Table A.4 contains the digitized stages for Grant Creek in a tabular format. Table A.5 lists the digitized data for Prairie Creek where it crosses Western Patrol Road. In addition, Table A.6 lists the stage of Prairie Creek where it crosses over the northern LAP boundary, as observed on the staff gage installed there. Clearly seen in both of the continuous hydrographs is the large peak from the flood of November 1990. The maximum peak is obscured because it occurred after the end of the recording period; thus, it is actually somewhat higher than that shown in the hydrographs. At the time of the flood, water rose up over the road surrounding the bridge over Prairie Creek and caused considerable damage to the gravel road. The bridge and the stage recorder installation were undamaged.

3.3.2 Stream Velocity Profiling

Although stream velocity profiling was not included in the funded work plan, it was recognized as a critical component of stream discharge calculations. Thus, arrangements were made to conduct stream velocity profiling on several different dates at each of the three stream stage monitoring locations. The stream velocities were measured with an electric conductance-type current meter by an individual wading across the stream and taking measurements at one- to two-foot intervals at 0.6 of total stream depth. Initially, the equipment was field tested and the cross-section markers were installed on November 9, 1990. Although cross-section markers installed before the flood were bent over by flood waters and debris, they remained in place.

These markers, with an engineering tape measure strung between them, provided a consistent frame of reference for stream velocity profiling on the different measuring dates.

3.3.3 Stream Stage-Discharge Calculations

Stream stage-discharge for each velocity profiling date was calculated using the midpoint method (Buchanan and Somers 1973). This method calculates discharge by multiplying the measured stream velocity by the calculated average cross-sectional area of the stream velocity measurement point, as shown below:

$$q_i = v_i d_i \left[\frac{(b_i - b_{i-1})}{2} + \frac{(b_{i+1} - b_i)}{2} \right] \tag{2}$$

where:

q_i = discharge through partial section i,

v_i = velocity at location i,

d_i = stream depth at location i,

b_{i-1} = cross-stream distance to location i-1,

b_i = cross-stream distance to location i, and

b_{i+1} = cross-stream distance to location i+1.

Table 4 summarizes the results of the stream velocity profiling exercises. Figures 7, 8, and 9 are stage-discharge relationships for the three stream monitoring locations.

TABLE 4 Calculated Stream Stage-Discharge Relationships Based on Stream Velocity Profiles

	Grant Creek		Prairie Creek West		Prairie Creek East	
Date	Stage[a]	Discharge[b]	Stage[a]	Discharge[b]	Stage[a]	Discharge[b]
11/26/90	1.17	2.74[c]	1.18	17.98	2.50	10.06
12/07/90	1.25	8.85	1.56	52.95	NA[d]	NA
3/14/91	1.32	13.14	1.55	52.76	2.70	30.02
4/03/91	1.15	7.02	1.30	35.60	2.52	18.09

[a]Stage is in units of feet.

[b]Discharge is in units of cubic feet per second.

[c]Spurious data point.

[d]Not available.

Given the data points shown in Table 4 (shown as stars in Figures 7, 8, and 9), a stage-discharge regression equation was calculated by the graphics program Grapher for each of the stream monitoring locations. Subsequently, regression statistics were calculated to evaluate the regressions for "goodness-of-fit" or R^2 (Davis 1986). The following equations were used:

$$R^2 = \frac{SS_R}{SS_T} \tag{3}$$

where:

SS_R = sum of squares of residuals due to regression, and

SS_T = total sum of squares of residuals;

and

$$SS_R = \sum_{i=1}^{n} (\hat{Y}_i - \bar{Y})^2 \tag{4}$$

$$SS_T = \sum_{i=1}^{n} (Y_i - \bar{Y})^2 \tag{5}$$

where:

$\bar{Y}$ = mean value of the data,

Y_i = ith value of the data, and

$\hat{Y}_i$ = i_{th} value of the regression function.

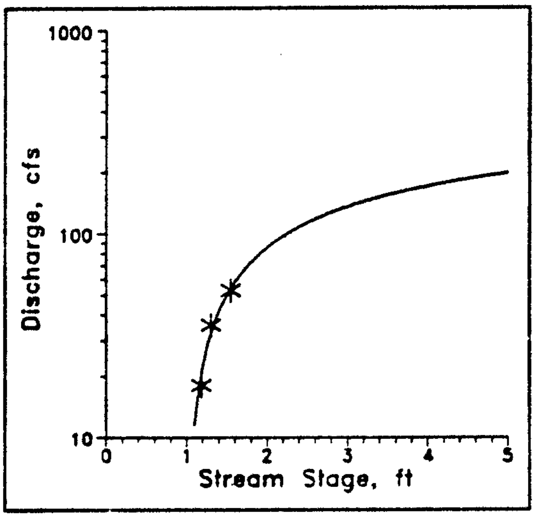

FIGURE 7 Stage-Discharge Relation for Prairie Creek at Western Patrol Road (Best-fit line is natural logarithmic.)

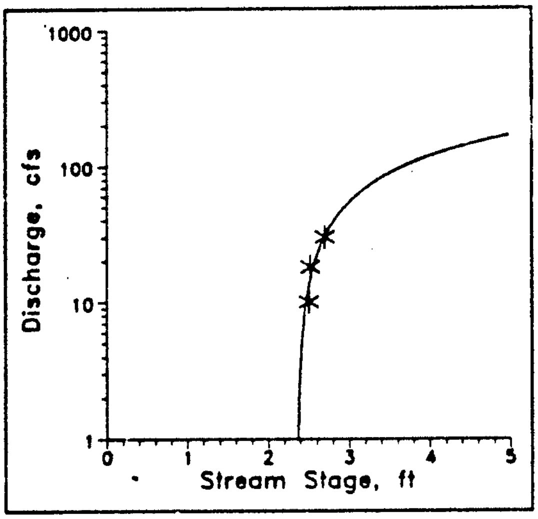

FIGURE 8 Stage-Discharge Relation for Prairie Creek East (Best-fit line is natural logarithmic.)

The R^2 statistic is valid only in the region where data occur and should not be interpreted to apply to curves extending beyond the data. The results of this statistical analysis are shown in Table 5. At the 1% level, there is no difference between the R^2 statistic for linear or logarithmic curve fitting at the three sites. However, current scientific understanding predicts that stream discharge should be a logarithmic function of stream stage.

To calculate the stream discharge at the monitoring points, the regression equations were applied to the digitized stream stage data listed in Tables A.4 and A.5. For Grant Creek at Western Patrol Road, total discharge for May 1990 through March 1991, expressed as volume over the Grant Creek basin area, was 7.02 in. For Prairie Creek at western Patrol Road, it was first necessary to subtract the influx onto the site across the northeastern border of the LAP. Because the stage data from the western monitoring station had a much finer time resolution, an influx calculation based on those data was made. The calculation was based on the assumption that the stage and discharge of a downstream point is a function of the stage and discharge of an upstream point. First, a linear regression equation relating upstream discharge to downstream discharge was calculated. In this case, the equation *upstream* = 0.573365 × *downstream* - 0.933887 had an R^2 of 0.99. Next, net runoff from the Prairie Creek basin on JAAP was calculated based on the the total runoff at Prairie Creek West as a function of stage there, minus total runoff at Prairie Creek East as a function of runoff at Prairie Creek West. This calculation resulted in the total discharge for May 1990 through March 1991, expressed as a volume of 7.51 in. over the Prairie Creek basin area.

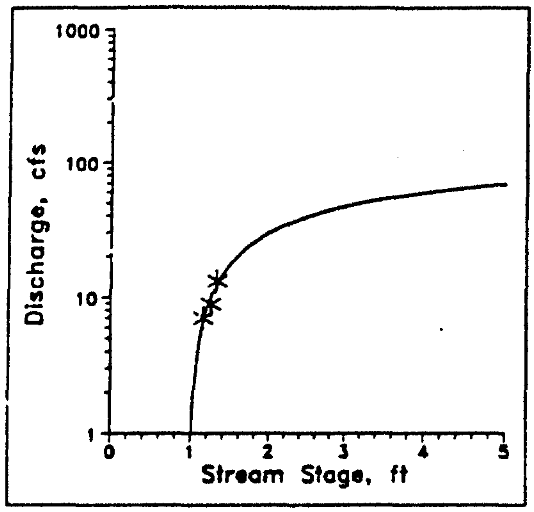

FIGURE 9 Stage-Discharge Relation for Grant Creek at Western Patrol Road (Best-fit line is natural logarithmic.)

3.4 CHANGE IN SURFACE WATER STORAGE

For the one-year study period, changes in surface water storage were assumed to be zero for both basins. In the Grant Creek basin, no significant perennial surface water bodies exist, and changes in surface water storage should therefore be nonexistent. In the Prairie Creek basin, Kemery Lake is the only significant perennial surface water body. It is a man-made lake, which was used for fire prevention during times of past production. However, throughout the decades, it has continued to infill with sediment and to shrink in area. Gaging records of

TABLE 5 Stage-Discharge Regression Equation Coefficients and Statistics

	$Y = a_1 \ln(x) + b_1$			$Y = l_2 (x) + b_2$		
Gaging Station	a_1	b_1	R^2_1	a_2	b_2	R^2_2
Grant Creek	42.5207	.591293	0.94	34.7866	33.4667	0.94
Prairie Creek West	123.889	-.321546	1.04	90.145	-85.6481	1.04
Prairie Creek East	225.488	-193.606	0.93	86.5384	-203.302	0.93

Kemery Creek for the study period are not known to exist. For the time span of the study, it is assumed that lake volume and lake levels did not change appreciably. In addition to Kemery Lake, the area of the Prairie Creek basin on the manufacturing side intermittently floods. Ephemeral lakes often form in the region of MW201 and MW104 (Plate 1). Following the flood of November 1990, almost the entire Prairie Creek basin on the manufacturing side was under water. However, for the purpose of this analysis, these ephemeral lakes are considered to be exactly periodic phenomena, with a period of one year, which results in no net change in surface water storage on an annual basis. This simplifying assumption was made to further the progress of the analysis.

3.5 CHANGE IN GROUNDWATER STORAGE

Water level data were collected over 13 months, from March 1990 through March 1991. These data are tabulated in Table A.7. Figures 10 and 11 show groundwater levels in the Pleistocene system of JAAP during March 1990 and March 1991, respectively. In general, this shallow system made up of glacial tills to the east and glacial outwash to the west mimics the area topography. Flow is controlled to a large extent by locally incised streams. Figures 12 and 13 show groundwater levels in the Silurian system of JAAP during March 1990 and March 1991, respectively. The Silurian system shows some control from surface streams near the middle and to the west of JAAP. Flow directions in this system are approximately east-northeast to west-southwest. For all of these figures, the data are insufficient to define groundwater levels on the eastern side of the LAP at JAAP. This shortcoming is related to the locations of appropriate wells.

Figures 14 and 15 show the change in water levels in the two systems sitewide, given the changes in individual wells from March 1990 through March 1991. Positive values indicate a relative rise in water levels, while negative values indicate a drop in water levels. In both the Pleistocene and Silurian systems, increased water levels occur to the north in the LAP, while decreases occur to the west. These decreases are more widespread and more westward in the Silurian system, where large drops are observed on the MAN. In the Pleistocene system, the magnitude of the rise is larger, while in the Silurian the magnitude of the drop is larger. These features may be lag effects of the drought of the summer of 1988. Below-normal net recharge to the upland systems may have resulted in a groundwater deficit, which has worked its way down through the system from the upland recharge areas to local groundwater discharge zones. Meanwhile, a year of average rainfall has resulted in rises in water levels in the upland recharge areas.

Changes in groundwater storage for the shallow systems were calculated after Schicht and Walton (1961) from the relation:

$$\Delta S_g = \Delta h \; Y_g \tag{6}$$

where:

Δh = change in groundwater stage, and

Y_g = gravity yield.

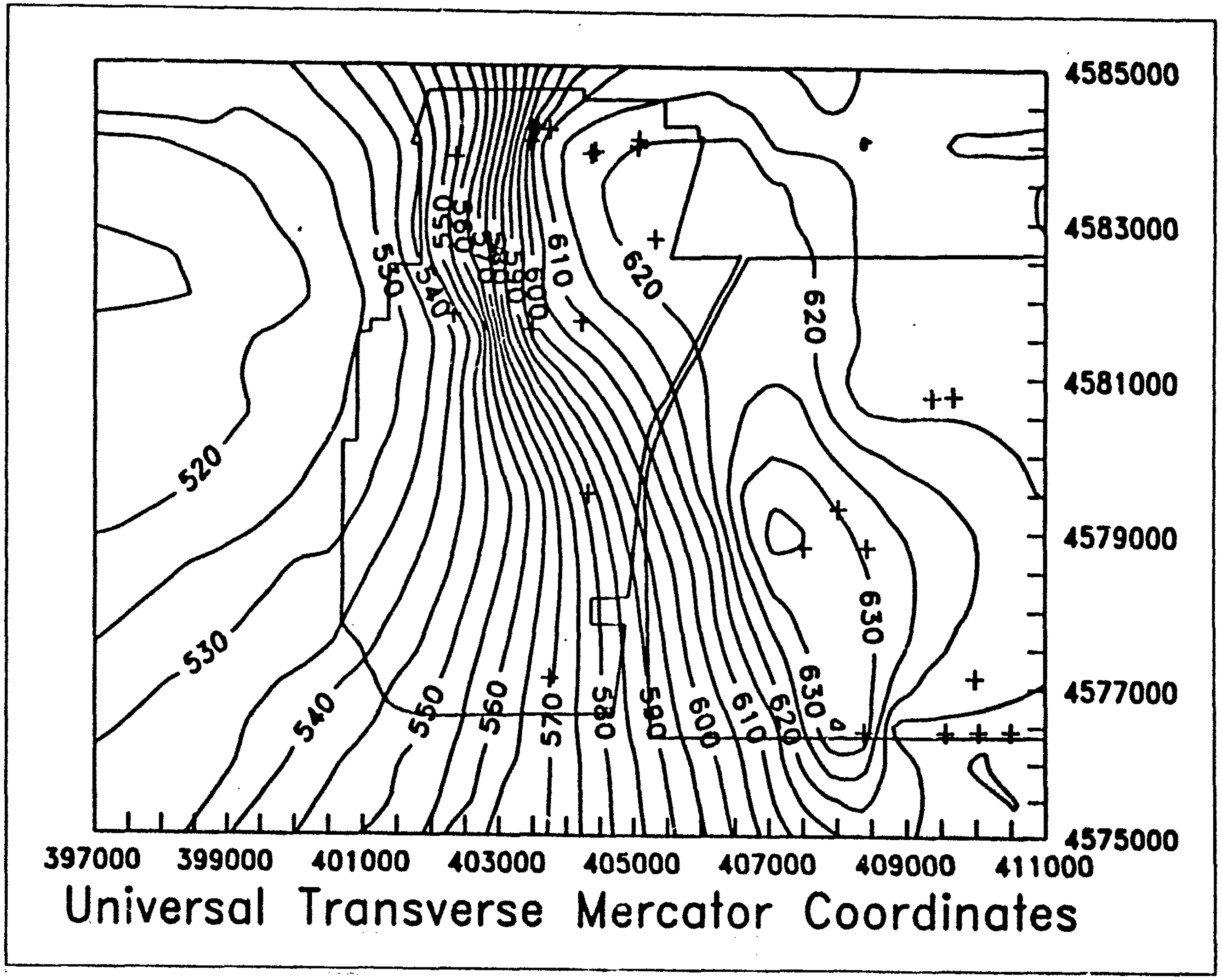

FIGURE 10 Pleistocene System Groundwater Stage at JAAP, March 1990

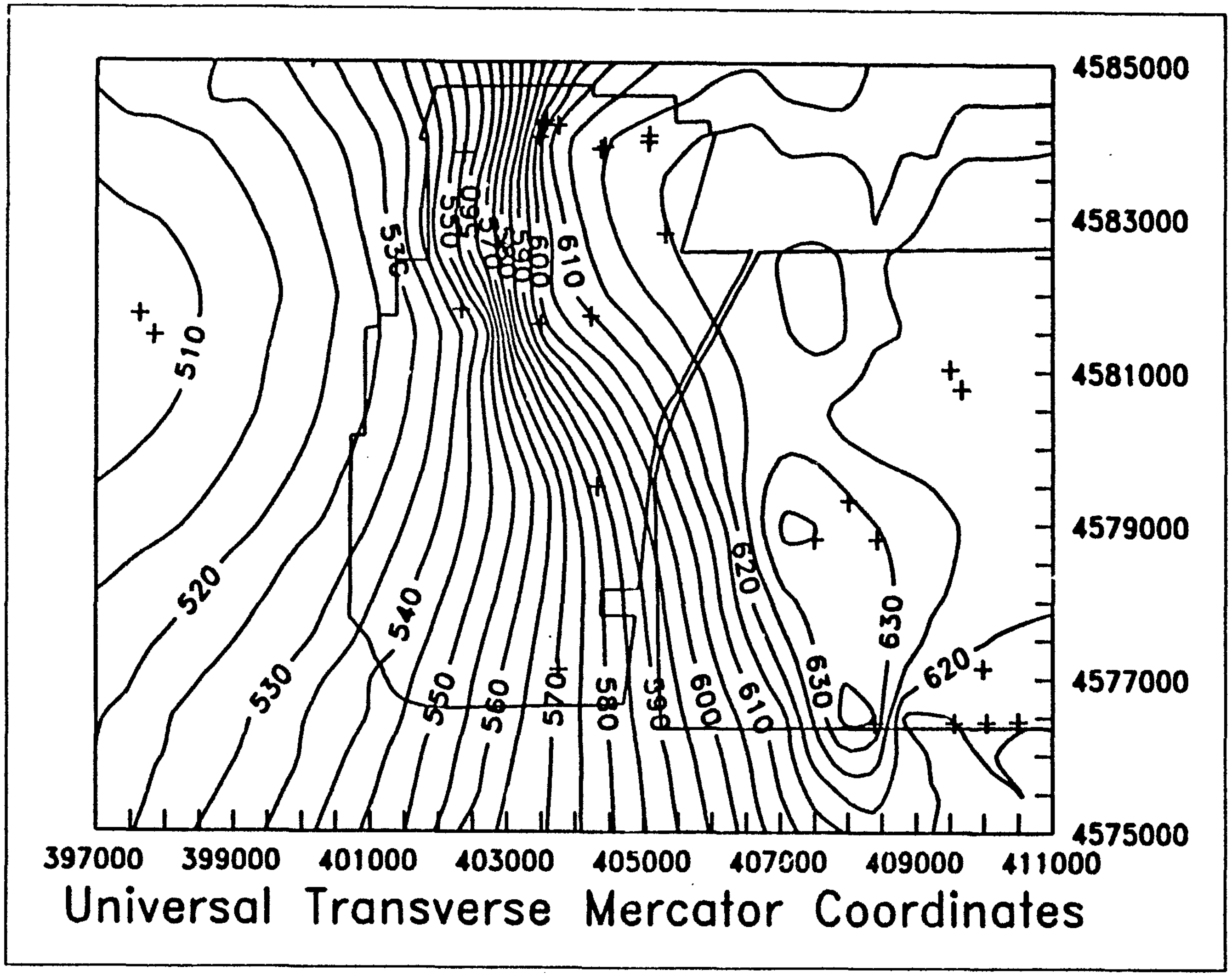

FIGURE 11 Pleistocene System Groundwater Stage at JAAP, March 1991

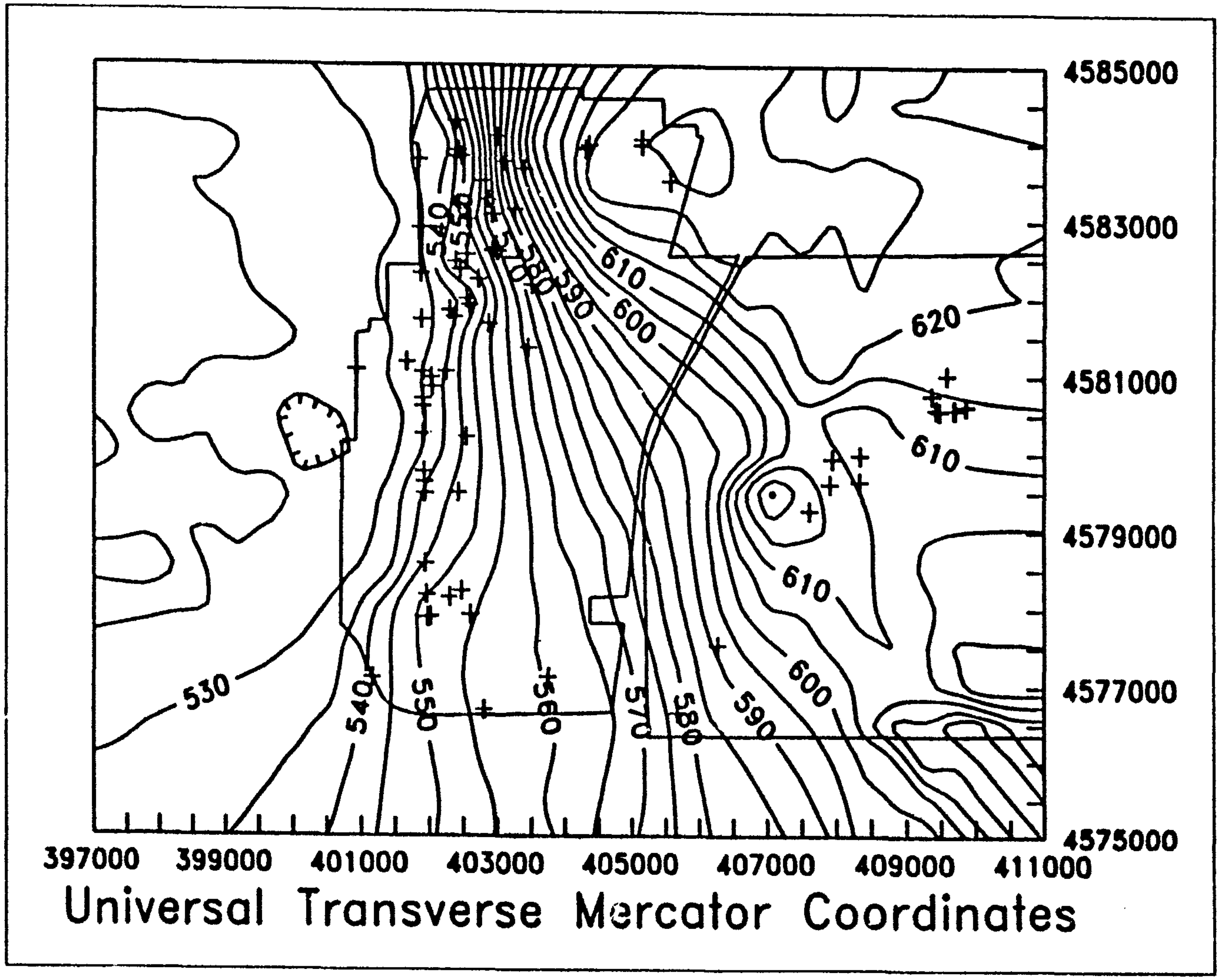

FIGURE 12 Silurian System Groundwater Stage at JAAP, March 1990

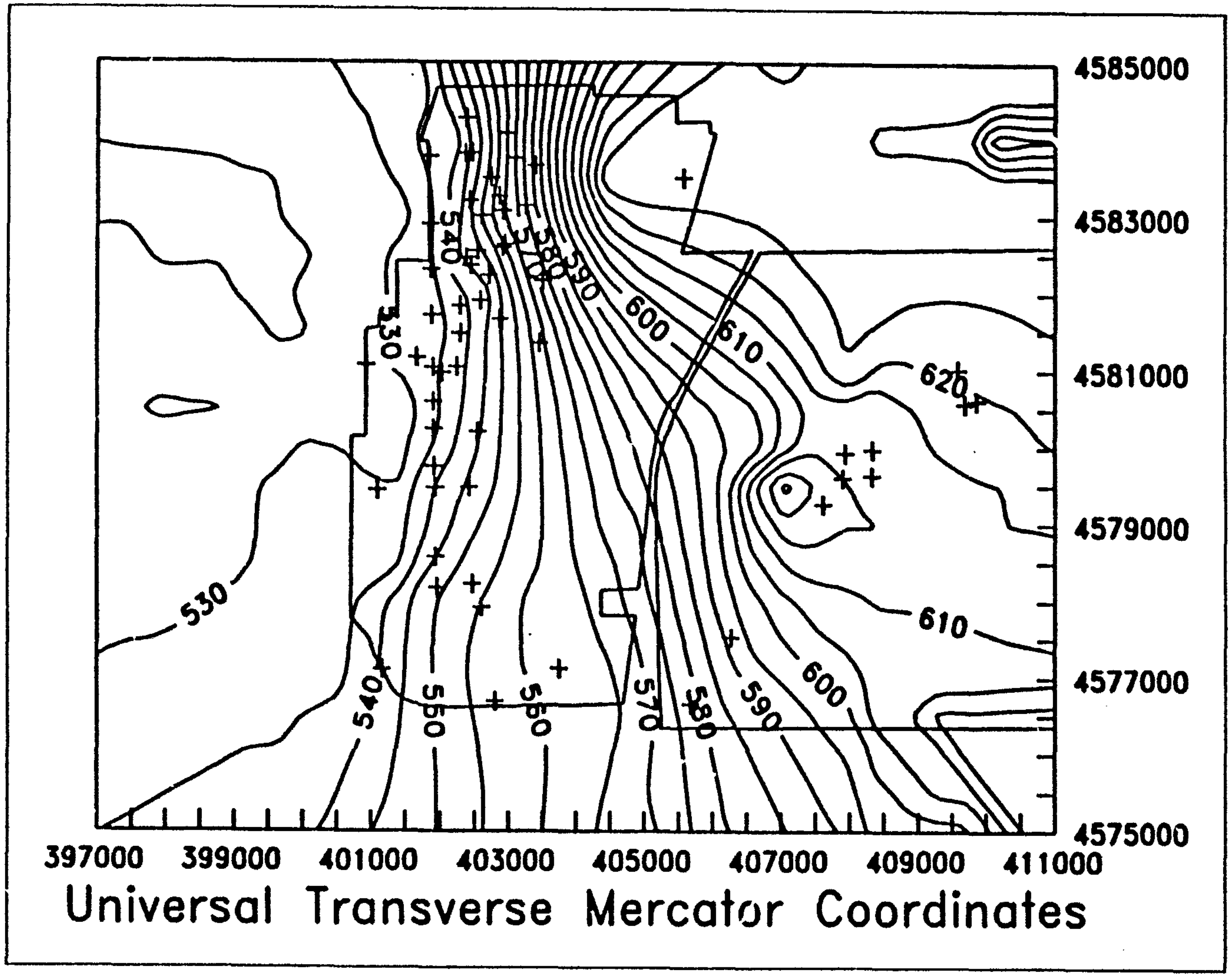

FIGURE 13 Silurian System Groundwater Stage at JAAP, March 1991

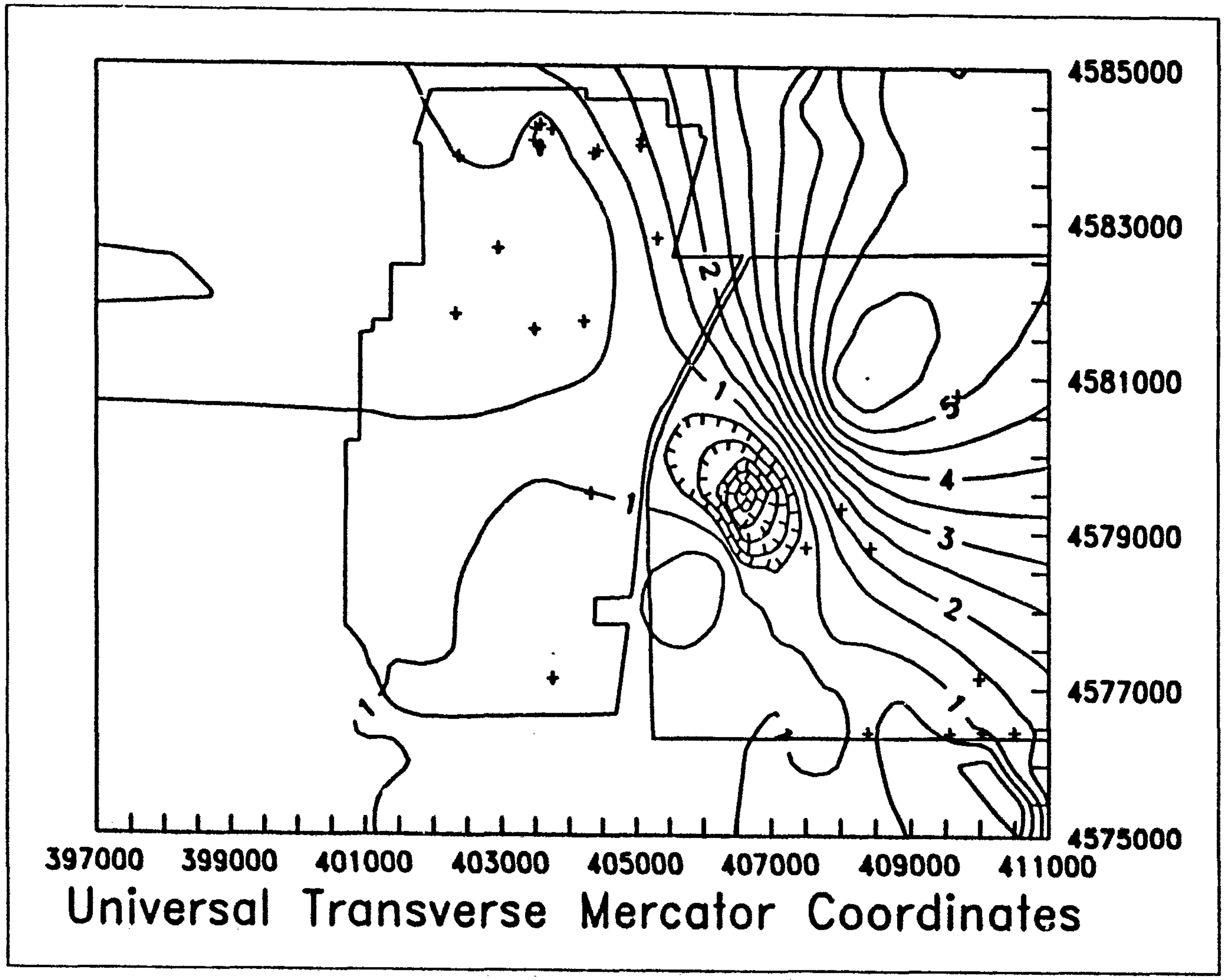

FIGURE 14 Change in Stage in the Pleistocene System, March 1990 through March 1991

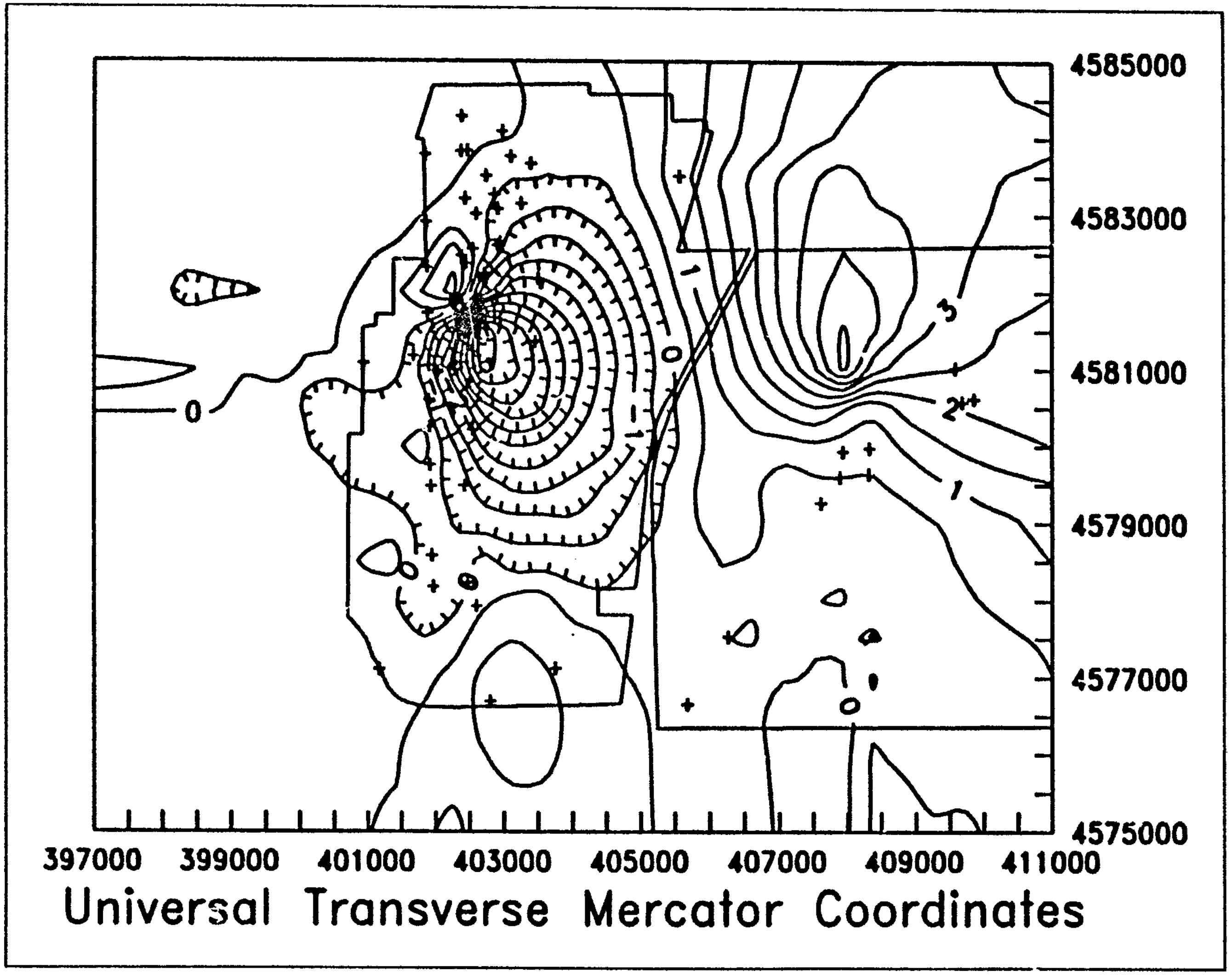

FIGURE 15 Change in Stage in the Silurian System, March 1990 through March 1991

Gravity yield is defined as the volume of water draining from a volume of material over a time interval. As the time interval of drainage increases, the gravity yield increases assymptotically toward a maximum. However, Schicht and Walton (1961) found that gravity yields rarely attained maximum values. For their model of the JAAP, Tsai et al. (1986) used a storage coefficient for all hydrogeologic units of 20%. In a regional model, Filley (1985) used a value of 0.01%/ft of saturated thickness for unconfined aquifers in till, and 0.005%/ft of saturated thickness for unconfined aquifers in Silurian dolomite in Illinois. Schicht and Walton (1961) found that gravity yields ranged from 1% to 12% in glacial sediments in three small watersheds in Illinois.

In the absence of site-specific data, and based on these numbers, a value of 5% was used for the Pleistocene glacial sediments at the site, and 0.5% was used for the Silurian dolomites. These numbers at times will be higher, and at other times lower. Also, the values in the Pleistocene sediments will be higher in the Henry Formation outwash and lower in the Wedron Till. Because fluid potentials in much of the Silurian system are hydrostatic much of the time, an unconfined approximation was used. Taken together, these parameter approximations lead to useful, but approximate, results. The data reported in Table 6 are based on well levels in the two surface water hydrologic basins. The figures show water levels and changes sitewide. The basins of Grant and Prairie creek form a small part of the whole of the deep and extensive regional groundwater system.

Sufficiently detailed data describing the deep system at JAAP are scarce. The Illinois State Water Survey (1991) maintained a continuous recorder on a deep well at JAAP until mid-November 1991. Readings of water levels in deep production wells on site taken by JAAP staff are not sufficiently accurate to monitor changes in water levels. In fact, for the one-year monitoring period, no changes in water level for any deep well were ever recorded. JAAP personnel stated that their method of measurement has an accuracy of about ± 5 ft.

Figure 16 is a graph of historical water elevations in well 33N9E-1.5e1, located on the manufacturing side of JAAP. Note the cultural effects of wartime ammunitions production and associated groundwater pumpage on the deep aquifer system as manifested in the sharp drop in water levels associated with World War II, the Korean War, and the Vietnam War. Although long-term water levels have shown a persistent decline, present-day levels show less fluctuation than in times of production.

Figure 17 shows an apparent relation between groundwater levels in the shallow Pleistocene system, as recorded in MW109, and the stage of Prairie and Grant creeks at Western Patrol Road. Note that seasonal trends of declining water levels throughout the summer and rising water levels in the fall are observed in both the surface water and groundwater systems.

TABLE 6 Change, in Inches, in Groundwater Stage during the Study Period

Basin	Pleistocene	Silurian	Total
Grant Creek	0.11	0.01	0.12
Prairie Creek	0.21	0.05	0.26

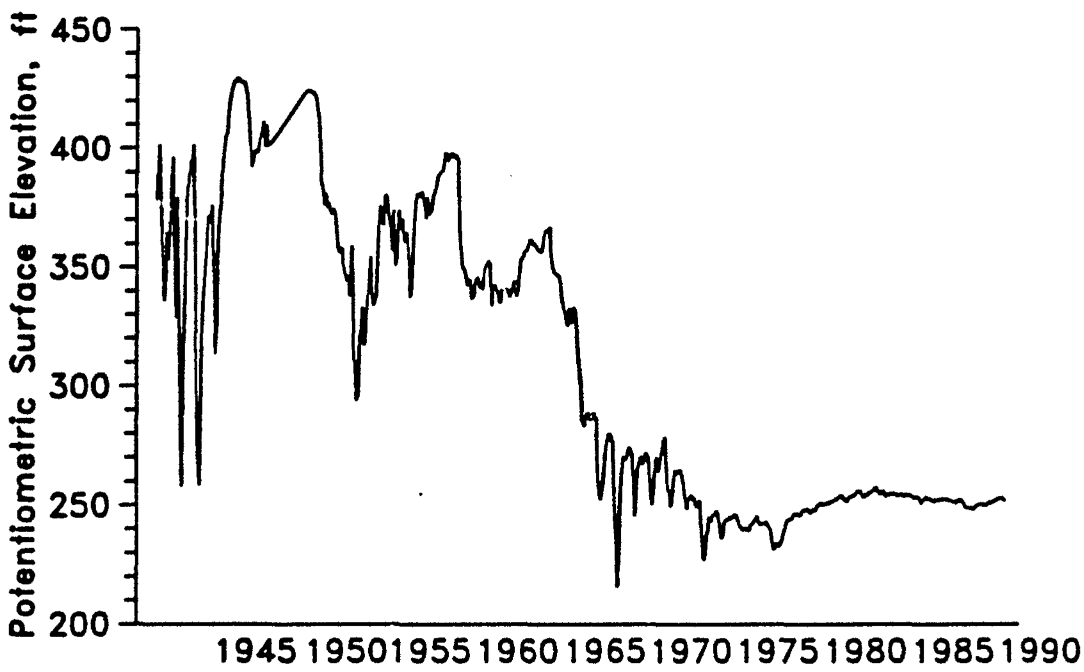

FIGURE 16 Historical to Recent Water Levels in Deep Well 33N9E-1.5e1 at JAAP (Note the drops associated with high production rates during WW II, the Korean War, and Vietnam War. Current levels are below the lowest levels of the 1940s.) (Source: ISWS Database 1991)

Unfortunately, the time resolution of the groundwater data does not allow for the computation of a lag time between groundwater recharge and groundwater runoff to surface water streams. Clearly, much of the flashiness of the surface flows would not be seen in groundwater levels. However, field observations show that shallow groundwater systems respond rapidly to large recharge events.

Overall, large fluctuations are seen in groundwater levels during the 13-month measurement period. For example, excluding a suspect reading on April 1990, water levels in well MW178, installed in the Silurian system on the LAP, fluctuated by over 17 ft. For the purpose of numerical model calibration, "average" annual water levels in wells may represent the system poorly.

3.6 UNDERFLOW

Underflow is the quantity of water bypassing surface water monitoring systems. In this study, underflow may have occurred either via surface tributaries that merged with the trunk

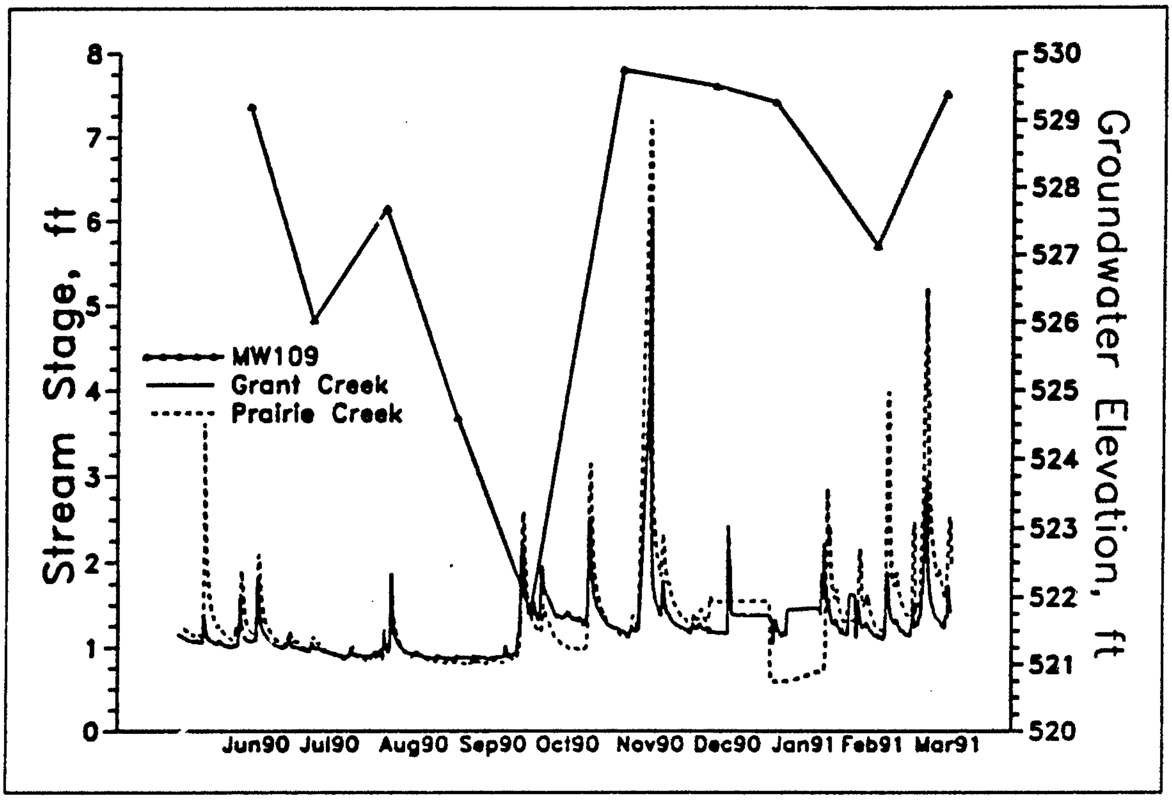

FIGURE 17 Stream Stages of Prairie and Grant Creeks at Western Patrol Road and Groundwater Elevation of MW109, a Well Finished in the Pleistocene near the Surface Water Divide between These Two Streams

stream downstream from the monitoring station or via groundwater that discharged into streams downstream of the monitoring station. These quantities are difficult to assess. However, if flow is routing around the streams in the groundwater system, it is possible to approximate the flux using a Darcian approach. In this study, good well pairs for gradient calculations did not exist near the stream-stage-monitoring stations.

Table 7 lists the gradients between well pairs identified as the best available for this calculation. A vertical conductivity of the Pleistocene tills of 0.04 ft/yr was used by Filley (1985) in a regional groundwater flow model. This number would be considerably larger for glacial outwash. For the Silurian dolomite, Filley used a vertical conductivity of 15 ft/yr, while the Maquoketa Shale had a vertical conductivity of 0.003 ft/yr. With these numbers and the gradients in Table 7, average Pleistocene-to-Silurian flow is calculated as 0.04 in./yr -- 0.06 in./yr from well pair MW176/MW178, and 0.01 in./yr from well pair MW151/MW152. This value applies to only the Prairie Creek basin because the well pairs occur in that basin. Unfortunately, this value does not indicate what the fluxes are from the shallow system to the deep system. To calculate the flux to the deep system, a simplifying assumption was made that the hydrogeology of the unit of greatest resistance (i.e., the Maquoketa), controls the downward flow from the Pleistocene to the Maquoketa. The average vertical flux is 1×10^{-3} in./yr --

TABLE 7 Calculated Gradients in Groundwater Systems at JAAP

Month	Shallow Well MW151	Deep Well MW152	Gradient (25.50')[a]	Shallow Well MW176	Deep Well MW178	Gradient (26.20')
			Pleistocene to Silurian			
3/90	558.96	557.93	-4.0E-02	Dry	621.02	NA[b]
4/90	558.14	557.66	-1.9E-02	622.81	629.74	2.6E-01[c]
5/90	558.58	558.14	-1.7E-02	624.87	621.70	-1.0E-01
6/90	557.51	557.28	-9.0E-03	620.87	618.24	-1.0E-01
7/90	NA	556.88	NA	NA	616.33	NA
8/90	NA	557.33	NA	NA	612.76	NA
9/90	555.73	555.45	-1.1E-02	Dry	608.86	NA
10/90	556.70	556.29	-1.6E-02	Dry	609.70	NA
11/90	NA	NA	NA	626.98	622.40	-1.7E-01
12/90a	559.15	558.42	-2.9E-02	625.61	622.11	-1.3E-01
12/90b	558.82	558.07	-2.9E-02	623.97	620.68	-1.3E-01
12/90c	NA	NA	NA	622.84	618.33	-1.7E-01
1/91	557.20	556.93	-1.1E-02	620.15	617.54	-1.0E-01
2/91	558.47	557.65	-3.2E-02	621.25	618.71	-9.7E-02
3/91	559.99	559.29	-2.7E-02	630.60	626.03	-1.7E-01
Average			-2.2E-02			-1.3E-01

Month	Shallow Well MW130	Deep Well MW155	Gradient (127.00')	Shallow Well MW169	Deep Well MW168	Gradient (116.00')
			Pleistocene to Maquoketa			
3/90	525.13	519.39	-4.5E-02	NA	NA	NA
4/90	524.03	516.25	-6.1E-02	NA	502.62	NA
5/90	524.61	519.13	-4.3E-02	505.48	503.17	-2.0E-02
6/90	523.19	521.48	-1.3E-02	504.67	502.41	-1.9E-02
7/90	521.96	517.71	-3.3E-02	504.40	502.37	-1.7E-02
8/90	521.69	517.98	-2.9E-02	505.20	502.60	-2.2E-02
9/90	520.22	515.82	-3.5E-02	504.22	502.34	-1.6E-02
10/90	521.44	517.89	-2.8E-02	504.76	502.58	-1.9E-02
11/90	524.97	520.03	-3.9E-02	506.87	503.93	-2.5E-02
12/90a	524.91	519.13	-4.6E-02	506.05	503.33	-2.3E-02
12/90b	524.65	517.78	-5.4E-02	505.27	503.29	-1.7E-02
12/90c	524.42	518.75	-4.5E-02	505.11	502.89	-1.9E-02
1/91	523.3[illegible]	517.65	-4.5E-02	504.46	NA	NA
2/91	524.65	518.46	-4.9E-02	505.05	504.95	-8.6E-04
3/91	525.14	518.47	-5.3E-02	506.97	503.23	-3.2E-02
Average			-4.1E-02			-1.8E-02

[a]Length term in the gradient calculation.

[b]Not available.

[c]Spurious data point that indicates upward flow from the Silurian into the Wedron Till. This condition is unlikely at this location.

1.5×10^{-3} in./yr from well pair MW130/MW155, and 6.5×10^{-4} in./yr from well pair MW169/MW168. This value is negligible when compared to the magnitude of other terms in the hydrologic budget and is considered zero for this analysis.

3.7 SOURCES OF ERROR

From the perspective of the hydrologic budget calculations, a number of sources of error were identified that contributed to uncertainties in the individual terms of the equation. However, none of these errors in any way diminishes the usefulness of the numbers in the database for the primary goal of supporting numerical modeling efforts.

For precipitation, the difficulties associated with using regional data for a site-specific analysis are highlighted by the significant differences in rainfall that occurred between at least two of the recording stations on most months. Rain events can often be localized, especially in the summer months when convective storms dominate. Note that January 1991 data were missing from the Hydraulic Master Database. Corps personnel suggest that this may have been caused by equipment malfunctions during the cold winter season. However, January precipitation can be significant. As shown in Table A.3, total precipitation at Brandon Road Dam in January 1990 was 2.49 in.

The continuous stream-stage hydrographs have periods of flatness in the late winter data. These features are due to surface water freezing inside of the stilling wells of the stage recorder installation.

The conversion of the stage data to discharge values was subject to some inaccuracies. First, because of the intercepts of the regression equations, and because the natural log of a number less than 1 is negative, some of the lower recorded stages produced negative discharge values. By taking these stages to be essentially zero discharge, total discharge for Grant Creek changed from 6.36 in. to 7.02 in. Applying this same assumption to Prairie Creek changed the total from 5.33 in. to 7.51 in. This means that negative discharge values totaled 0.66 in. for Grant Creek and 2.18 in. for Prairie Creek. These significant discrepencies could be mitigated by refinement of the stage-discharge relations through an increased number of low flow-stream velocity measurements. Low flow stage-discharge data would help to alleviate this artifact. In addition, Prairie Creek discharge would be considerably better constrained if the Prairie Creek East site where Prairie Creek flows onto the LAP were equipped with continuous-stage recording equipment.

In addition to poorly defined stage-discharge functions at both extremes of flow, other sources of error to the runoff calculations exist. In particular, surface water in the basin may bypass the gaging station without being monitored, by going through channels that intersect the trunk stream downstream of the monitoring stations. Also, surface water may leak into the groundwater system, recharging water table aquifers. Both of these sources of error are accounted for in the "underflow" term of Eq. 1. However, another source of error that is unaccounted for is ungaged discharges to surface water streams, including sewage treatment plant effluent or industrial process water.

Finally, the problem of missing data affected the analyses. First, precipitation data for January 1991 were unavailable. January precipitation can be significant -- more than 2 in. fell in January 1990. In addition, stream stage data for March and April 1990 were unavailable.

March 1991 data were used, in the hope that they might be representative of March 1990 stream flow. This still leaves one month of stream flow unaccounted for. These missing data reduce the magnitude of both sides of the hydrologic budget equation.

3.8 SUMMARY OF RESULTS

Table 8 summarizes the hydrologic components of the budget solved for in this study. The hydrologic budgets of Prairie and Grant creeks, based on the data acquired during the study, do not precisely balance. Because errors emanate from several sources, some of which may be offsetting, the actual imbalance might be larger. Even though these data and resulting budget figures are approximate, and given the constraints previously discussed, the overall imbalance shown in Table 8 is not severe. For the Grant Creek basin, a deficit on the right hand side of the hydrologic budget Eq. 1 of 1.22 in. is 3.9% of total precipitation. This discrepency may be largely due to ungaged stream discharge in the Grant Creek basin. Similarly, for the Prairie Creek basin, a 0.59-in. deficit is 1.9% of total precipitation. This may be a result of insufficient gaging data for Prairie Creek at the LAP border. These values can serve as guidelines for evaluating the results of numerical modeling exercises. By comparing the results of numerical modeling exercises with these estimates and other data, model validity can be assessed.

This study showed that the shallow groundwater systems at JAAP are very dynamic and that water levels are transient on an annual time scale. During the course of the budget year, groundwater levels, on average, rose overall in both the Pleistocene and Silurian systems. Data from the deep Cambro-Ordovician system were inadequate to evaluate the system's behavior during this period. Water flow in the shallow systems appears to be controlled by topography and streams. Clearly, surface water and shallow groundwater systems are coupled. Groundwater gradients in the Pleistocene are strongly controlled by the type of glacial sediments. In the Wedron Till, the equipotentials are closely grouped, and gradients are steep. In the Henry Formation outwash, equipotentials are widely spaced and gradients are lower. However, water movement is expected to be rapid in these sediments because of their high transmissivity.

TABLE 8 Components, in Inches, of the Hydrologic Budget for the Study Period[a]

Basin	P	ET	R	ΔS_s	ΔS_g	U
Grant Creek	31.45	23.09	7.02	0.0	0.12	0
Prairie Creek	31.45	23.09	7.51	0.0	0.26	?

[a]Notation defined in Eq. 1.

4 CONCLUSIONS AND RECOMMENDATIONS

The goal of the study was to provide an adequate database to support groundwater flow and contaminant transport modeling at JAAP. To satisfy this goal, a large amount of data was collected, assembled into an electronic database, and processed. The data show that on an annual time scale, significant changes occur in water levels in the shallow groundwater systems. In at least one case, water levels fluctuated more than 17 ft during the course of the year. In addition, the linkage of the shallow groundwater systems to the surface water systems was seen. The use of a single "average" annual water level for calibration targets in a groundwater flow modeling exercise will probably produce unsatisfactory results. Further, it is clearly observed that, while some regions of an aquifer are undergoing net annual recharge, others may be losing water on an annual basis. The implications for groundwater modeling are that steady-state assumptions for groundwater flow would be invalid for predictions on the order of years.

Existing data were used to calculate additional hydrologic budgets. Although the budgets did not precisely balance, the results may serve to help evaluate the validity of numerical flow-modeling exercises at JAAP. There were a number of sources of error in the study. With incremental efforts, these sources of error could be reduced, and the results provided in this report could be refined.

First, the inaccuracies and uncertainties associated with an off-site rain gage could be eliminated through installation and maintenance of on-site gages. Second, additional stream velocity profiles at low and high stream stages would greatly enhance the viability of the stream discharge data. Third, data from the deep Cambro-Ordovician hydrogeologic system should be acquired. Because the Illinois State Water Survey has been unable to fund continued stage monitoring of 33N9E-1.5e1 -- a deep well on the MAN -- a continuous stage recorder should be installed. Other deep-well data points should be monitored on the site, with better accuracy than presently exists. To better constrain the stream runoff term in Prairie Creek, a continuous recorder should be installed where Prairie Creek flows onto the LAP. For both the Grant and Prairie Creek basins, consideration should be given to establishing continuous gaging stations at locations that minimize the underflow term. Finally, in recognition of the long-term fluctuations of groundwater systems at JAAP, a minimal quarterly series of groundwater level measurements is recommended. These measurements should use the same standard reference points developed during this study, so that the data are comparable.

The values in the database created by the study period can serve as calibration targets for groundwater flow modeling. The estimated hydrologic budget calculations can be used as guidelines in validating numerical fluid flow models for JAAP. Additional supplements to the database would help to improve the accuracy of the hydrologic budget calculations and to further enhance their usefulness as validation tools.

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*Requests for this document should be referred to the U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Md.

APPENDIX

DATA TABLES

TABLE A.1 Groundwater Monitoring Points at JAAP

Well No.	Ground Elevation	Casing Height	T[a]	R[b]	S[c]	ISP[d] North	ISP[d] East	UTM[e] North	UTM[e] East	Note
MW101	554.3	2.63	33	9	14	1701284	547146	4576688	402800	
MW102	534.5	3.58	33	9	15	1702562	541757	4577103	401164	
MW103	537.6	3.74	33	9	3	1710257	541412	4579449	401095	
MW104	546.2	2.92	33	9	11	1705173	544364	4577886	401970	1
MW105	552.5	2.66	33	9	11	1705327	546426	4577923	402599	
MW106	539.7	2.26	33	9	11	1706132	544320	4578178	401961	
MW107	549.1	3.53	33	9	11	1706303	545979	4578223	402468	1
MW108	540.8	3.00	33	9	2	1710455	545754	4579489	402419	
MW109	529.9	3.90	33	9	2	1710409	544154	4579482	401931	
MW110	530.5	3.60	33	9	2	1711314	544090	4579758	401916	
MW111	529.4	2.48	33	9	2	1714084	543988	4580603	401898	
MW112	531.7	2.63	34	9	35	1715535	543972	4581045	401900	
MW113	533.7	2.63	34	9	35	1715578	545090	4581053	402240	
MW114	552.4	3.29	34	9	36	1716655	549055	4581362	403453	
MW115	530.8	3.08	34	9	35	1717770	543865	4581726	401877	
MW116	532.6	3.04	34	9	35	1719719	543810	4582320	401870	
MW117	526.9	3.25	34	9	26	1721630	543728	4582903	401854	
MW118	531.2	2.79	34	9	26	1724523	543638	4583785	401840	
MW119	535.5	4.19	34	9	26	1726169	545379	4584278	402378	
MW120	584.7	2.48	34	9	25	1725931	549058	4584189	403498	
MW121	571.8	3.69	34	9	26	1725399	548991	4584027	403475	
MW122	537.4	2.44	34	9	26	1723668	546595	4583511	402737	
MW123	532.9	2.94	34	9	35	1720532	546000	4582558	402541	
MW124	533.9	2.67	34	9	35	1718406	546162	4581909	402580	
MW125	562.6	3.28	34	9	26	1722500	548301	4583147	403251	
MW126	561.7	3.20	34	9	35	1719318	549173	4582173	403502	
MW127	600.3	3.19	34	9	36	1717828	551540	4581708	404216	
MW128	619.1	2.67	34	10	30	1721399	555083	4582779	405312	
MW129	561.1	2.95	33	9	12	1710578	551992	4579497	404320	
MW130	525.7	2.70	34	9	34	1715595	540791	4581078	400931	
MW131	620.4	2.95	33	10	4	1715051	569467	4580778	409665	
MW132	603.7	2.73	33	10	5	1712366	565126	4579980	408330	
MW133	599.0	2.32	33	10	5	1712205	563836	4579937	407936	
MW134	609.7	3.97	33	10	5	1711130	563723	4579610	407897	
MW135	631.8	3.47	33	10	5	1711263	565121	4579644	408323	
MW136	600.8	2.17	33	10	8	1709992	562812	4579268	407614	
MW137	631.4	2.23	33	10	8	1710150	564113	4579310	408011	
MW138	622.9	2.78	33	10	8	1708489	562485	4578811	407507	
MW139	642.0	3.28	33	10	9	1708531	565507	4578810	408428	
MW140	579.6	2.81	33	10	18	1704218	558492	4577529	406270	
MW141	565.5	2.06	33	10	18	1701300	556588	4576649	405677	
MW142	612.7	3.56	33	10	21	1700700	565504	4576424	408390	
MW143	635.1	3.63	33	10	16	1703113	570681	4577135	409979	
MW144	638.7	2.92	33	10	16	1700761	569310	4576426	409555	
MW145	638.4	3.95	33	10	15	1700812	570877	4576433	410028	
MW146	615.9	3.25	33	10	15	1700868	572406	4576443	410494	
MW147	558.1	4.45	34	9	26	1723203	548615	4583359	403350	1
MW148	553.5	3.28	34	9	26	1724216	548743	4583667	403394	
MW149	584.7	2.33	34	9	25	1725912	549865	4584179	403744	
MW150	640.4	2.33	34	10	30	1723792	555876	4583505	405565	
MW151	560.4	2.61	33	9	13	1702729	550251	4577114	403753	
MW152	560.3	2.79	33	9	13	1702734	550241	4577115	403750	
MW153	534.9	3.60	33	9	11	1707449	544234	4578580	401941	
MW154	529.1	4.01	33	9	2	1712931	544028	4580251	401904	
MW155	527.2	2.42	34	9	34	1715611	540797	4581083	400932	

TABLE A.1 (Cont'd)

Well No.	Ground Ele-vation	Casing Height	T[a]	R[b]	S[c]	ISP[d] North	ISP[d] East	UTM[e] North	UTM[e] East	Note
MW156	538.0	4.13	34	9	35	1717638	547097	4581671	402862	
MW157	531.5	3.29	34	9	35	1718147	555203	4581835	402287	1
MW158	531.7	3.13	34	9	35	1718171	545196	4581842	402285	
MW159	533.5	4.23	34	9	35	1718669	545906	4581991	402503	1
MW160	538.4	4.24	34	9	35	1719496	546559	4582240	402706	
MW161	534.4	4.62	34	9	35	1719911	545681	4582370	402441	
MW162	533.8	4.01	34	9	35	1720533	546018	4582558	402546	1
MW163	535.3	4.03	34	9	26	1722024	546137	4583012	402590	
MW164	541.5	3.88	34	9	26	1722265	547182	4583081	402909	
MW165	540.2	3.83	34	9	26	1722872	547005	4583266	402858	
MW166	543.3	3.88	34	9	26	1724503	547767	4583760	403098	
MW167	541.8	3.11	34	9	26	1725564	547356	4584084	402978	
MW168	510.2	3.73	34	9	32	1715214	530506	4581010	397795	
MW169	508.2	3.36	34	9	32	1716662	530614	4581451	397835	
MW170	515.8	2.62	34	9	32	1717563	529908	4581729	397624	
MW171	613.9	3.34	33	10	4	1714331	568844	4580561	409472	1
MW172	612.3	2.79	33	10	4	1714406	569532	4580581	409682	
MW173	611.9	3.13	33	10	4	1714395	569562	4580578	409691	1
MW174	611.5	2.85	33	10	4	1714551	570086	4580623	409851	
MW175	630.1	3.23	33	10	4	1714973	568478	4580759	409363	1
MW176	639.4	3.33	33	10	4	1715879	568909	4581033	409499	
MW177	613.7	2.47	33	10	4	1714331	568858	4580579	409422	1
MW178	639.5	3.54	33	10	4	1715879	568931	4581025	409579	
MW201	544.1	2.08	33	9	11	1705208	544503	4577896	402013	
MW202	530.9	1.77	33	9	2	1710900	544124	4579632	401924	1
MW203	531.9	2.13	33	9	2	1714416	543984	4580704	401898	1
MW204	523.7	1.83	33	9	3	1712360	541528	4580089	401140	5
MW205	531.6	1.82	34	9	34	1715944	543203	4581173	401667	
MW206	532.3	1.47	34	9	34	1717009	545234	4581488	402291	
MW207	553.1	2.49	34	9	36	1717450	549143	4581604	403484	
MW208	534.9	2.69	34	9	35	1720232	545470	4582469	402378	
MW209	534.7	1.92	34	9	26	1722679	545580	4583214	402423	
MW210	564.7	2.35	34	9	26	1720703	547504	4582603	403000	1
MW211	566.4	2.60	34	9	26	1720831	547312	4582643	402942	
MW212	566.7	1.86	34	9	26	1720715	547228	4582608	402916	1
MW213	564.6	1.78	34	9	26	1720700	547481	4582602	402993	1
MW214	566.0	1.50	34	9	26	1720835	547332	4582644	402948	
MW215	566.3	1.32	34	9	26	1720702	547209	4582604	402910	
MW216	536.9	2.15	34	9	35	1718662	546019	4581988	402538	1
MW217	536.4	2.72	34	9	35	1718737	546018	4580211	402538	
MW218	591.8	2.24	34	9	25	1726080	549289	4584233	403569	
MW219	538.3	1.99	34	9	26	1724944	545394	4583905	402377	1
MW220	537.6	2.72	34	9	26	1724949	545532	4583906	402419	1
MW221	538.1	2.15	34	9	26	1724705	545674	4583831	402461	
MW222	539.2	1.83	34	9	26	1724681	545362	4583825	402366	
MW223	604.9	2.23	34	9	25	1725104	551713	4583924	404303	1
MW224	604.5	2.02	34	9	25	1725273	551871	4583975	404352	1
MW225	613.0	2.13	34	9	25	1725054	552114	4583907	404425	
MW226	609.5	2.05	34	9	25	1724942	551909	4583874	404362	
MW227	620.3	1.42	34	10	30	1725556	554243	4584050	405076	
MW228	621.2	2.79	34	10	30	1725540	554470	4584044	405145	1
MW229	621.7	2.56	34	10	30	1725303	554464	4583972	405142	1
MW230	617.8	1.83	34	10	30	1725286	554205	4583968	405063	
MW231	548.4	1.64	33	9	11	1706030	545419	4578142	402296	1
MW232	533.2	2.15	34	9	35	1715312	544391	4580975	402026	

TABLE A.1 (Cont'd)

Well No.	Ground Ele-vation	Casing Height	T[a]	R[b]	S[c]	ISP[d] North	ISP[d] East	UTM[e] North	UTM[e] East	Note
MW233	532.7	2.37	34	9	35	1714926	544449	4580857	402042	1
MW234	531.4	2.05	34	9	35	1717895	545424	4581757	402353	1
MW235	531.4	1.85	34	9	35	1718018	545334	4581795	402326	
1F3		1.30								4
26-9										2,4
AEHA01										4
AEHA08										4,5
AEHA14		3.88								4
AEHA15		3.08								4
FARMWELL		0.71								1,4
FW-6										4,5
FW-63E										4,5
FW-64E										4,5
FW-65E										4,5
FW-65-30										4,5
G1		2.91								4
G1A		3.55								4
G2		3.00								4
G2A		3.31								4
G3		3.88								4
G3A		3.76								4
GC 1		3.55								4
GC 3		3.10								4
GC 4		2.10								6
GC 4NW										4
GC 4SE										4
GC 5										6
GC 6		2.38								4
M 1		1.98								4
M 2		1.43								4
M 3		1.71								4
WSW-1	539.0		34	9	35			4580959	402626	2,7
WSW-2	531.8		34	9	35			4580968	401864	2,7
WSW-3	528.0		34	9	34			4580977	401254	2,7
WSW-4			34	9	34			4580974	400618	2,7
WSW-5	572.0		33	9	1			4580299	404237	2,7
WSW-6	577.0		34	9	36			4581059	404236	2,7
WSW-7	601.0		34	9	36			4581821	404235	2,7
WSW-8	606.0		34	9	25			4584189	404235	2,7
WSW-9	589.0		34	9	25			4583342	404235	2,7
WSW-10	591.0		34	9	25			4584116	404235	2,7
East Well	646.5		33	10	9			4578877	409863	3,7
West Well	641.5		33	10	9			4579304	409260	3,7
33N9E-1.5e	570.3	1.20	33	9	1			4580340	404066	8

[a]Township.

[b]Range.

[c]Section.

[d]Illinois state plane.

[e]Universal transverse mercator.

TABLE A.1 (Cont'd)

Notes:

1. Removed from monitoring list during optimization.
2. Data from deep production wells are recorded by site personnel.
3. Data from these wells are obtained when they are accessible.
4. Geologic logs and elevation data are not available.
5. Location is uncertain.
6. Conflicts exist between field labels of wells and map labels.
7. Elevation reported; position calculated from Illinois State Water Survey (ISWS) Bulletin No. 34 (1941) and ISWS Bulletin No. 41 (1943).
8. Elevation is from ISWS (personal communication, 1991); position is calculated from well identification.

TABLE A.2 Geology and Hydrostratigraphy of Groundwater Wells at JAAP

Well No.	Depth (ft) to Contact x; Rock Type at Contact[a] x=1	x=2	x=3	x=4	Total Depth of Well (ft)	Hydrostratigraphic Unit
MW101	6.0 D				42.0	Silurian Dolomite Aquifer
MW102	15.3 D				28.0	Silurian Dolomite Aquifer
MW103	5.1 D				41.0	Silurian Dolomite Aquifer
MW104	27.0 D				28.0	Silurian Dolomite Aquifer
MW105	24.6 D				28.5	Silurian Dolomite Aquifer
MW106	21.0 D				30.0	Silurian Dolomite Aquifer
MW107	5.8 D	11.1 U	17.0 D		25.5	Silurian Dolomite Aquifer
MW108	9.0 D				27.0	Silurian Dolomite Aquifer
MW109	8.0 D				44.0	Silurian Dolomite Aquifer
MW110	9.5 D				27.5	Silurian Dolomite Aquifer
MW111	10.5 D				54.0	Silurian Dolomite Aquifer
MW112	7.6 D				29.0	Silurian Dolomite Aquifer
MW113	5.2 D				28.0	Silurian Dolomite Aquifer
MW114	17.2 D				32.0	Silurian Dolomite Aquifer
MW115	2.3 D				28.0	Silurian Dolomite Aquifer
MW116	5.6 D				27.0	Silurian Dolomite Aquifer
MW117	11.2 DW				27.7	Silurian Dolomite Aquifer
MW118	2.1 D				23.0	Silurian Dolomite Aquifer
MW119	5.8 D				25.5	Silurian Dolomite Aquifer
MW120					41.5	Pleistocene
MW121					31.2	Pleistocene
MW122	6.5 D				27.5	Silurian Dolomite Aquifer
MW123	10.5 D				27.0	Silurian Dolomite Aquifer
MW124	5.5 D				15.0	Silurian Dolomite Aquifer
MW125	26.3 D				27.0	Silurian Dolomite Aquifer
MW126	26.0 D				34.0	Silurian Dolomite Aquifer
MW127					27.5	Pleistocene
MW128					31.5	Pleistocene
MW129					24.5	Pleistocene
MW130	9.5 D				27.5	Silurian Dolomite Aquifer
MW131					23.0	Pleistocene
MW132	18.0 D				27.5	Silurian Dolomite Aquifer
MW133	19.5 D				27.5	Silurian Dolomite Aquifer
MW134					27.0	Silurian Dolomite Aquifer
MW135					26.5	Silurian Dolomite Aquifer
MW136	11.1 D				27.5	Silurian Dolomite Aquifer
MW137					27.0	Pleistocene
MW138					30.0	Pleistocene
MW139					39.5	Pleistocene
MW140	21.5 D				28.0	Silurian Dolomite Aquifer
MW141	6.6 D				27.5	Silurian Dolomite Aquifer
MW142					26.5	Pleistocene
MW143					28.5	Pleistocene
MW144					34.0	Pleistocene
MW145					38.5	Pleistocene
MW146					24.0	Pleistocene
MW147					27.0	Pleistocene
MW148	13.0 D				27.0	Silurian Dolomite Aquifer
MW149					36.5	Pleistocene
MW150					36.5	Silurian Dolomite Aquifer
MW151	11.0 DW				11.0	Pleistocene
MW152	11.5 DW				36.5	Silurian Dolomite Aquifer
MW153	5.5 D				5.5	Silurian Dolomite Aquifer
MW154	5.0 D				9.1	Silurian Dolomite Aquifer

TABLE A.2 (Cont'd)

Well No.	Depth (ft) to Contact x; Rock Type at Contact[a] x=1	x=2	x=3	x=4	Total Depth of Well (ft)	Hydrostratigraphic Unit
MW155	9.1 D	117.9 SH	129.3 D		151.5	Maquoketa Confining Unit
MW156	5.3 D				5.4	Silurian Dolomite Aquifer
MW157	6.5 D				10.5	Silurian Dolomite Aquifer
MW158	5.0 D	23.7 DW			30.2	Silurian Dolomite Aquifer
MW159	5.7 DW				11.0	Silurian Dolomite Aquifer
MW160	6.1 DW				6.3	Silurian Dolomite Aquifer
MW161	7.7 D				7.7	Silurian Dolomite Aquifer
MW162	4.0 DW				4.0	Silurian Dolomite Aquifer
MW163	5.9 DW				6.1	Silurian Dolomite Aquifer
MW164	6.0 D				6.0	Silurian Dolomite Aquifer
MW165	5.0 DW				5.3	Silurian Dolomite Aquifer
MW166	9.7 D				11.1	Silurian Dolomite Aquifer
MW167	19.5 DW				19.5	Silurian Dolomite Aquifer
MW168	26.3 DW	30.5 SH	46.7 D	91.4 SH	151.5	Maquoketa Confining Unit
MW169					35.5	Pleistocene
MW170					36.5	Pleistocene
MW171	8.0 D				8.0	Silurian Dolomite Aquifer
MW172	11.0 D				36.0	Silurian Dolomite Aquifer
MW173					12.0	Pleistocene
MW174	15.0 DW				15.0	Silurian Dolomite Aquifer
MW175	20.0 DW				20.0	Silurian Dolomite Aquifer
MW176	20.8 D				20.8	Pleistocene
MW177	6.5 D				31.0	Silurian Dolomite Aquifer
MW178	20.5 D				47.0	Silurian Dolomite Aquifer
MW201	24.0 D				66.5	Silurian Dolomite Aquifer
MW202	6.0 D				29.0	Silurian Dolomite Aquifer
MW203	5.5 D				25.5	Silurian Dolomite Aquifer
MW204	4.5 D	34.0 U			40.5	Silurian Dolomite Aquifer
MW205	4.0 D				27.0	Silurian Dolomite Aquifer
MW206	11.3 D				36.5	Silurian Dolomite Aquifer
MW207					15.5	Pleistocene
MW208	4.0 D				27.0	Silurian Dolomite Aquifer
MW209	11.1 D				34.5	Silurian Dolomite Aquifer
MW210					18.0	Pleistocene
MW211					22.0	Pleistocene
MW212					20.0	Pleistocene
MW213	29.8 D	49.5 U			53.0	Silurian Dolomite Aquifer
MW213	30.0 D				37.0	abandoned
MW214	27.0 D	46.5 U	50.5 D		53.5	Silurian Dolomite Aquifer
MW215	30.5 D				53.1	Silurian Dolomite Aquifer
MW216	11.0 D				11.0	Silurian Dolomite Aquifer
MW217	13.4 D				36.0	Silurian Dolomite Aquifer
MW218					32.5	Pleistocene
MW219	5.8 D				29.0	Silurian Dolomite Aquifer
MW220	4.0 D				27.3	Silurian Dolomite Aquifer
MW221	3.0 D				26.0	Silurian Dolomite Aquifer
MW222	6.0 D				27.0	Silurian Dolomite Aquifer
MW223					17.5	Pleistocene
MW224					18.0	Pleistocene
MW225					32.5	Pleistocene
MW226					20.0	Pleistocene
MW227					20.0	Pleistocene
MW228					17.0	Pleistocene
MW229					16.0	Pleistocene

TABLE A.2 (Cont'd)

Well No.	Depth (ft) to Contact x; Rock Type at Contact[a] x=1	x=2	x=3	x=4	Total Depth of Well (ft)	Hydrostratigraphic Unit
MW230					17.5	Pleistocene
MW231					16.0	Pleistocene
MW232	7.0 D				37.0	Silurian Dolomite Aquifer
MW233	2.5 D				25.5	Silurian Dolomite Aquifer
MW234	3.0 D				26.0	Silurian Dolomite Aquifer
MW235					11.3	Pleistocene
WSW-1						
WSW-2						
WSW-3						
WSW-4						
WSW-5						
WSW-6						
WSW-7						
WSW-8						
WSW-9						
WSW-10						
WSW-11						
WSW-12						
34N9E-1.5e						

[a]D - dolomite, WD - weathered dolomite, SH - shale, L - limestone, SS - sandstone, U - unlithified sediment or void, S - sand, and GR - gravel.

Sources: Well log data are from the Illinois State Geological Survey, Donohue & Associates, and Dames & Moore.

TABLE A.3 Precipitation at Brandon Road Dam during the Monitoring Period

Day	Jan90	Feb90	Mar90	Apr90	May90
1	0.01	0.18	0.00	0.01	M[a]
2	M	0.21	0.00	0.14	0.00
3	0.00	0.00	0.00	0.00	0.00
4	0.31	0.00	0.00	0.00	0.88
5	0.01	0.00	0.00	M	0.57
6	0.00	0.00	0.16	0.00	0.05
7	M	M	0.00	0.00	0.00
8	0.00	0.01	0.01	0.00	0.00
9	0.00	0.00	1.03	0.00	0.00
10	M	0.00	0.32	0.42	M
11	0.00	0.00	0.76	M	0.05
12	0.00	0.00	0.01	0.00	0.35
13	0.00	0.00	0.00	0.00	0.88
14	0.00	0.01	0.02	0.17	0.00
15	0.00	0.85	0.18	0.00	0.01
16	0.00	0.05	0.00	0.01	0.35
17	0.59	0.01	0.00	0.04	0.10
18	0.01	M	0.00	0.00	0.00
19	0.00	0.00	M	0.00	0.00
20	0.05	0.00	0.00	0.01	0.40
21	0.07	0.00	0.00	0.37	0.00
22	0.00	0.25	0.01	0.00	0.00
23	0.00	M	0.35	0.00	0.00
24	0.01	M	0.02	0.00	0.00
25	1.08	M	0.00	0.00	0.05
26	0.35	M	0.00	0.01	0.73
27	M	0.00	0.00	0.00	0.00
28	0.00	M	0.00	0.00	0.00
29	M		0.12	0.01	0.00
30	M		0.25	0.00	0.00
31	0.00		0.01		0.00
Total	2.49	1.57	3.25	1.19	4.42

Day	Jun90	Jul90	Aug90	Sep90	Oct90
1	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00
3	0.01	0.00	0.00	0.00	0.00
4	0.00	0.00	M	0.00	0.59
5	0.00	0.00	0.20	0.00	0.07
6	M	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	M	M
8	M	M	0.00	0.00	0.40
9	0.15	0.00	0.00	M	1.15
10	0.00	0.78	0.00	0.00	1.17
11	0.00	M	0.00	0.00	M
12	0.00	0.28	0.00	0.00	0.00
13	0.00	0.00	1.26	0.00	0.01
14	0.47	M	0.00	0.00	0.01
15	0.13	0.00	0.00	0.30	0.22
16	0.00	0.00	0.00	0.00	0.00
17	0.02	0.07	0.00	0.00	0.01

TABLE A.3 (Cont'd)

Day	Jun90	Jul90	Aug90	Sep90	Oct90
18	0.01	0.00	0.56	0.00	0.73
19	0.00	0.03	0.00	0.01	M
20	0.43	0.94	1.47	0.00	0.00
21	0.07	0.37	0.46	0.00	0.00
22	0.49	0.11	0.01	0.38	0.00
23	0.40	0.01	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.01
25	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00
27	0.01	0.00	0.00	0.00	0.00
28	0.37	0.00	0.00	0.00	M
29	0.90	0.00	1.10	0.02	0.00
30	0.18	0.00	0.00	0.01	0.00
31		0.00	0.00		0.00
Total	3.64	2.59	5.06	0.72	4.37

Day	Nov90	Dec90	Jan91	Feb91	Mar91
1	0.00	M	M	0.00	0.00
2	0.00	0.00	M	0.00	0.55
3	M	M	M	M	0.00
4	0.00	0.18	M	0.00	0.00
5	M	0.00	M	0.00	0.00
6	0.37	0.00	M	0.00	0.12
7	0.00	0.00	M	0.00	0.00
8	0.00	0.00	M	0.00	0.00
9	0.05	0.00	M	0.00	0.00
10	0.05	0.00	M	0.00	0.00
11	0.00	M	M	0.00	0.00
12	0.00	0.00	M	0.00	0.12
13	0.00	0.00	M	0.00	0.74
14	0.00	0.01	M	0.15	0.09
15	0.00	0.23	M	0.15	0.00
16	0.00	0.01	M	0.00	0.00
17	0.00	0.00	M	0.00	M
18	0.00	0.20	M	0.00	M
19	0.00	M	M	0.23	0.00
20	M	0.00	M	0.00	0.00
21	0.09	0.01	M	0.00	0.01
22	0.65	0.45	M	0.00	M
23	0.00	0.03	M	0.00	0.04
24	0.01	0.00	M	0.00	0.08
25	0.00	0.00	M	0.00	0.01
26	0.00	0.00	M	0.00	0.40
27	0.65	0.00	M	0.00	M
28	2.54	0.04	M	0.10	M
29	0.00	M	M		M
30	M	M	M		M
31		M	M		M
Total	4.41	1.17	M	0.63	2.16

[a]M means data are missing.

TABLE A.4 Digitized Stage of Grant Creek at Western Patrol Road[a]

Time	Stage	Time	Stage	Time	Stage
148.708	1.16	165.345	1.07	181.413	1.23
149.042	1.15	165.686	1.05	181.702	1.20
149.383	1.15	166.033	1.03	182.045	1.18
149.696	1.14	166.334	1.03	182.388	1.16
150.057	1.13	166.701	1.03	182.711	1.15
150.364	1.13	166.995	1.02	183.074	1.13
150.698	1.12	167.329	1.02	183.397	1.12
151.032	1.11	167.690	1.03	183.733	1.11
151.366	1.12	167.990	1.02	184.077	1.09
151.727	1.09	168.358	1.01	184.393	1.09
152.041	1.09	168.658	1.01	184.743	1.07
152.355	1.09	168.992	1.01	185.059	1.06
152.715	1.09	169.339	1.01	185.395	1.06
153.036	1.08	169.640	1.01	185.738	1.05
153.397	1.08	170.014	1.01	186.068	1.04
153.697	1.07	170.335	1.03	186.424	1.03
154.045	1.07	170.649	1.04	186.734	1.03
154.385	1.08	171.003	1.03	187.077	1.02
154.706	1.07	171.303	1.02	187.413	1.02
155.073	1.06	171.690	1.03	187.743	1.02
155.367	1.07	171.991	1.03	188.113	1.01
155.714	1.08	172.338	1.24	188.402	1.00
156.055	1.09	172.659	1.60	188.738	1.00
156.375	1.09	172.986	1.39	189.075	1.00
156.736	1.07	173.354	1.28	189.398	0.99
157.057	1.06	173.654	1.21	189.761	0.99
157.397	1.05	173.988	1.17	190.077	1.01
157.711	1.07	174.335	1.14	190.407	1.01
158.045	1.05	174.643	1.12	190.763	1.01
158.439	1.33	175.003	1.09	191.079	1.02
158.720	1.35	175.304	1.09	191.443	1.11
159.034	1.23	175.411	1.08	191.759	1.16
159.381	1.18	175.614	1.09	192.088	1.08
159.702	1.14	175.675	1.09	192.432	1.05
160.062	1.12	176.024	1.07	192.754	1.04
160.370	1.11	176.374	1.08	193.124	1.01
160.697	1.10	176.677	1.08	193.427	1.00
161.044	1.08	177.020	1.07	193.777	1.01
161.365	1.08	177.356	1.07	194.127	1.01
161.719	1.08	177.679	1.07	194.443	1.01
162.013	1.07	178.036	1.07	194.799	1.01
162.353	1.07	178.372	1.11	195.095	0.99
162.714	1.06	178.695	1.09	195.452	0.99
163.021	1.04	179.031	1.08	195.795	1.00
163.382	1.04	179.388	1.80	196.091	0.99
163.689	1.04	179.738	1.80	196.474	0.98
164.010	1.04	180.040	1.52	196.784	0.98
164.357	1.07	180.383	1.39	197.093	0.98
164.664	1.09	180.727	1.31	197.450	0.97
165.031	1.06	181.049	1.26	197.759	0.97

TABLE A.4 (Cont'd)

Time	Stage	Time	Stage	Time	Stage
198.136	0.96	214.169	0.90	230.788	1.00
198.439	0.96	214.496	0.90	231.095	1.11
198.775	0.96	214.844	0.89	231.416	1.86
199.132	0.96	215.158	0.93	231.542	1.87
199.421	0.95	215.499	0.93	231.823	1.52
199.804	0.95	215.820	1.01	232.145	1.36
200.120	0.99	216.154	0.95	232.507	1.24
200.443	1.07	216.495	0.93	232.815	1.18
200.793	1.06	216.809	0.92	233.130	1.12
201.109	1.03	217.143	0.92	233.486	1.10
201.486	1.01	217.484	0.91	233.814	1.09
201.789	1.00	217.799	0.91	234.183	1.05
202.139	0.99	218.160	0.91	234.498	1.03
202.482	0.98	218.460	0.89	234.819	1.03
202.791	0.99	218.801	0.92	235.161	1.01
203.181	0.99	219.122	0.91	235.503	0.99
203.477	0.98	219.457	0.91	235.885	0.99
203.578	0.98	219.824	0.91	236.186	0.98
203.593	0.99	220.125	0.90	236.535	0.96
203.814	0.99	220.453	0.90	236.877	0.96
204.148	0.98	220.787	0.89	237.212	0.96
204.469	0.96	221.101	0.89	237.560	0.95
204.850	0.97	221.462	0.89	237.842	0.94
205.151	0.96	221.770	0.90	238.204	0.94
205.525	0.94	222.110	0.90	238.559	0.92
205.812	0.95	222.465	0.90	238.847	0.93
206.173	0.95	222.766	0.89	239.222	0.93
206.521	0.94	223.120	0.89	239.544	0.92
206.822	0.94	223.441	0.90	239.893	0.93
207.203	0.94	223.782	0.91	240.234	0.93
207.490	0.94	224.123	0.91	240.576	0.94
207.805	0.93	224.437	0.90	240.938	0.94
208.172	0.93	224.805	0.96	241.240	0.93
208.500	0.93	225.105	0.94	241.622	0.91
208.867	0.93	225.440	0.96	241.923	0.92
209.175	0.93	225.794	0.95	242.245	0.91
209.496	0.92	226.095	0.90	242.627	0.90
209.864	0.92	226.449	0.95	242.929	0.90
210.164	0.92	226.770	0.94	243.311	0.91
210.532	0.92	227.124	0.90	243.606	0.90
210.826	0.92	227.438	1.00	243.941	0.89
211.167	0.91	227.766	0.97	244.296	0.89
211.521	0.90	228.140	0.91	244.597	0.89
211.822	0.90	228.434	1.01	245.006	0.88
212.197	0.90	228.762	1.22	245.308	0.88
212.497	0.90	229.116	1.08	245.643	0.88
212.825	0.90	229.444	1.01	245.992	0.88
213.193	0.90	229.805	0.99	246.280	0.88
213.480	0.89	230.106	0.97	246.635	0.88
213.861	0.89	230.427	0.96	246.943	0.87

TABLE A.4 (Cont'd)

Time	Stage	Time	Stage	Time	Stage
247.285	0.87	263.857	0.89	280.485	0.93
247.647	0.88	264.165	0.89	280.793	1.04
247.962	0.87	264.533	0.89	281.194	1.18
248.331	0.87	264.841	0.89	281.482	1.16
248.639	0.87	265.139	0.89	281.817	1.54
248.974	0.87	265.531	0.89	282.165	1.94
249.309	0.92	265.838	0.89	282.486	2.21
249.617	0.90	266.193	0.89	282.855	2.19
250.006	0.90	266.501	0.89	283.149	1.95
250.328	0.89	266.843	0.88	283.484	1.79
250.670	0.88	267.191	0.88	283.845	1.66
251.011	0.88	267.519	0.88	284.153	1.59
251.313	0.87	267.873	0.88	284.501	1.53
251.688	0.87	268.181	0.88	284.816	1.47
251.997	0.87	268.516	0.88	285.144	1.41
252.318	0.87	268.857	0.86	285.499	1.42
252.694	0.87	269.185	0.87	285.807	1.38
252.988	0.87	269.547	0.86	286.175	1.36
253.357	0.87	269.848	0.86	286.476	1.39
253.679	0.87	270.190	0.87	286.817	1.41
254.027	0.87	270.524	0.88	287.159	1.54
254.396	0.87	270.832	0.89	287.473	1.48
254.711	0.86	271.200	0.88	287.835	1.42
255.079	0.87	271.481	0.89	288.156	1.38
255.421	0.87	271.843	0.89	288.478	1.34
255.736	0.87	272.178	0.89	288.839	1.32
256.085	0.87	272.499	0.89	289.147	1.36
256.413	0.87	272.860	0.89	289.515	1.34
256.755	0.90	273.162	0.89	289.823	1.65
257.077	0.90	273.496	0.89	290.185	1.96
257.432	0.90	273.838	0.90	290.526	1.83
257.780	0.88	274.159	0.89	290.834	1.73
258.115	0.88	274.507	0.88	291.182	1.63
258.477	0.88	274.822	0.89	291.497	1.67
258.799	0.89	275.150	0.89	291.845	1.64
259.148	0.88	275.498	0.91	295.448	1.37
259.483	0.88	275.819	0.99	295.777	1.37
259.824	0.89	276.174	1.02	296.100	1.35
260.206	0.88	276.502	0.97	296.402	1.39
260.528	0.88	276.837	0.94	296.785	1.38
260.510	0.88	277.165	0.92	297.081	1.36
260.831	0.88	277.466	0.91	297.424	1.37
261.193	0.88	277.834	0.91	297.760	1.34
261.494	0.88	278.149	0.91	298.055	1.34
261.822	0.88	278.477	0.91	298.432	1.36
262.157	0.88	278.838	0.91	298.748	1.36
262.491	0.87	279.146	0.91	299.084	1.36
262.860	0.87	279.514	0.94	299.433	1.39
263.174	0.86	279.822	0.93	299.742	1.42
263.502	0.91	280.130	0.93	300.112	1.42

TABLE A.4 (Cont'd)

Time	Stage	Time	Stage	Time	Stage
300.414	1.42	317.127	1.25	336.306	1.38
300.770	1.40	317.449	1.25	336.691	1.67
301.120	1.37	317.805	1.24	336.992	1.80
301.429	1.35	318.094	1.24	337.318	1.64
301.792	1.35	318.444	1.23	337.651	1.53
302.087	1.32	318.787	1.23	337.951	1.48
302.430	1.34	319.102	1.23	338.310	1.43
302.793	1.35	319.472	1.22	338.610	1.40
303.109	1.34	319.774	1.22	338.937	1.40
303.478	1.34	320.124	1.21	339.282	1.39
303.774	1.31	320.446	1.20	339.583	1.36
304.117	1.32	320.776	1.19	339.935	1.34
304.460	1.36	321.139	1.19	340.235	1.33
304.775	1.35	321.441	1.19	340.568	1.31
305.145	1.34	321.790	1.19	340.914	1.30
305.441	1.30	322.120	1.19	341.208	1.30
305.770	1.33	322.449	1.17	341.567	1.28
306.133	1.26	322.825	1.16	341.854	1.28
306.455	1.27	323.128	1.16	342.180	1.27
306.805	1.32	323.450	1.15	342.526	1.26
307.100	1.29	323.800	1.15	342.833	1.26
307.430	1.33	324.129	1.15	343.186	1.26
307.793	1.49	324.478	1.19	343.473	1.24
308.149	2.40	324.808	1.24	343.799	1.24
308.498	2.52	325.144	1.23	344.139	1.23
308.814	2.51	325.473	1.23	344.445	1.23
309.110	2.09	325.796	1.21	344.817	1.23
309.479	1.87	326.165	1.20	345.111	1.23
309.788	1.76	326.468	1.19	345.418	1.22
310.145	1.66	326.804	1.19	345.777	1.21
310.467	1.59	327.146	1.23	346.064	1.21
310.783	1.57	327.462	1.21	346.397	1.20
311.126	1.57	331.500	3.97	346.723	1.19
311.448	1.47	331.830	5.02	347.037	1.18
311.818	1.46	331.833	5.02	347.376	1.17
312.127	1.44	331.920	6.17	347.676	1.17
312.443	1.43	332.164	5.02	348.016	1.22
312.806	1.41	332.155	5.02	348.348	1.30
313.108	1.39	332.436	2.56	348.655	1.28
313.484	1.36	332.755	2.10	349.008	1.25
313.780	1.35	333.043	1.75	349.314	1.23
314.116	1.33	333.376	1.67	349.615	1.23
314.445	1.32	333.721	1.60	349.974	1.22
314.768	1.31	333.989	1.56	350.267	1.22
315.097	1.30	334.381	1.52	350.626	1.26
315.433	1.28	334.674	1.49	350.933	1.28
315.783	1.27	335.027	1.46	351.253	1.28
316.139	1.27	335.327	1.43	351.579	1.27
316.435	1.26	335.660	1.40	351.893	1.25
316.818	1.25	336.012	1.38	352.226	1.23

TABLE A.4 (Cont'd)

Time	Stage	Time	Stage	Time	Stage
352.519	1.22	368.778	1.38	385.498	1.45
352.891	1.21	369.167	1.38	385.847	1.45
353.231	1.21	369.462	1.38	386.156	1.45
353.537	1.21	369.797	1.38	386.524	1.45
353.883	1.21	370.126	1.38	395.438	1.47
354.164	1.23	370.488	1.38	395.748	1.47
354.503	1.24	370.857	1.38	396.099	1.47
354.465	1.17	371.132	1.38	396.417	1.47
354.800	1.23	371.474	1.38	396.788	1.47
355.116	1.23	371.809	1.38	397.105	1.47
355.458	1.19	372.125	1.38	397.456	1.46
355.833	1.18	372.493	1.38	397.760	1.43
356.122	1.18	372.802	1.38	398.077	1.43
356.444	1.18	373.137	1.38	398.462	1.39
356.772	1.18	373.479	1.38	398.792	1.88
357.108	1.18	373.801	1.38	399.143	1.58
357.470	1.18	374.157	1.38	399.460	1.62
357.785	1.18	374.472	1.38	399.832	2.23
358.167	1.17	374.807	1.38	400.149	1.78
358.462	1.17	375.156	1.38	400.459	1.58
358.798	1.18	375.485	1.38	400.857	1.71
359.146	1.18	375.854	1.38	401.148	1.57
359.462	1.18	376.155	1.38	401.465	1.47
359.844	1.18	376.477	1.38	401.836	1.58
360.139	1.18	376.819	1.38	402.133	1.45
360.468	1.18	377.141	1.38	402.511	1.38
360.817	1.17	377.504	1.38	402.821	1.36
361.125	1.17	377.812	1.38	403.145	1.32
361.501	1.17	378.154	1.38	403.510	1.29
361.809	1.17	378.489	1.36	403.834	1.30
362.191	2.43	378.818	1.34	404.191	1.28
362.520	2.03	379.160	1.34	404.509	1.26
362.809	1.92	379.462	1.05	404.819	1.33
363.171	1.59	379.804	1.06	405.197	1.28
363.479	1.48	380.153	1.19	405.501	1.26
363.801	1.39	380.455	1.33	405.872	1.24
364.157	1.39	380.830	1.32	406.176	1.22
364.472	1.39	381.145	1.27	406.527	1.20
364.834	1.39	381.474	1.23	406.878	1.18
365.149	1.38	381.836	1.19	407.181	1.17
365.471	1.38	382.111	1.19	407.552	1.23
365.827	1.38	382.487	1.17	407.363	1.17
366.128	1.38	382.815	1.15	409.194	1.16
366.517	1.38	383.131	1.14	408.551	1.16
366.813	1.38	383.493	1.14	408.875	1.17
367.148	1.39	383.822	1.18	409.233	1.16
367.490	1.39	384.177	1.17	409.557	1.15
367.812	1.39	384.472	1.16	409.867	1.34
368.141	1.39	384.807	1.15	410.239	1.63
368.476	1.39	385.143	1.44	410.563	1.63

TABLE A.4 (Cont'd)

Time	Stage	Time	Stage	Time	Stage
410.886	1.63	427.267	1.34	441.777	2.66
411.217	1.63	427.602	1.33	442.000	2.67
411.561	1.63	427.923	1.32	442.185	2.17
411.912	1.63	428.299	1.30	442.505	1.82
412.236	1.63	428.600	1.29	442.844	1.72
412.614	1.61	428.975	1.29	443.132	1.65
412.911	1.13	429.277	1.33	443.477	1.56
413.222	1.12	429.605	1.32	443.771	1.52
413.606	1.28	429.967	1.29	444.071	1.50
413.903	1.49	430.255	1.25	444.442	1.44
414.254	1.42	430.603	1.24	444.711	1.41
414.585	1.35	430.945	1.23	445.075	1.38
414.929	1.30	431.280	1.20	445.363	1.36
415.273	1.25	431.635	1.19	445.689	1.34
415.570	1.23	431.923	1.20	446.021	1.34
415.928	1.27	432.292	1.20	446.341	1.34
416.259	1.26	432.620	1.19	446.680	1.32
416.576	1.24	432.922	1.17	446.942	1.32
416.934	1.29	433.290	1.15	447.287	1.30
417.278	1.29	433.598	1.15	447.607	1.27
417.608	1.26	433.933	1.16	447.894	1.26
417.946	1.24	434.268	1.15	448.227	1.25
418.250	1.21	434.583	1.15	448.572	1.24
418.634	1.20	434.965	1.14	448.866	1.23
418.938	1.20	435.253	1.15	449.205	1.35
419.275	1.18	435.608	1.22	449.499	1.38
419.613	1.17	435.950	1.26	449.806	1.36
419.944	1.16	436.265	1.52	450.151	1.74
420.308	1.14	436.647	1.41	450.471	1.65
420.619	1.14	436.915	1.25	450.803	1.53
420.963	1.14	437.263	1.25	451.078	1.44
421.314	1.13	437.605	1.30	451.263	1.42
421.638	1.16	437.927	1.30		
421.989	1.12	438.295	1.27		
422.306	1.11	438.597	1.31		
422.650	1.13	438.932	1.38		
422.994	1.11	439.260	1.36		
423.318	1.11	439.588	1.49		
423.696	1.11	439.950	1.71		
423.622	1.09	440.251	1.64		
423.937	1.12	440.580	2.03		
424.279	1.12	440.868	2.67		
424.594	1.19	440.995	2.67		
424.955	1.58	441.054	2.78		
425.250	1.88	441.100	2.67		
425.572	1.89	441.333	2.67		
425.934	1.66	441.484	2.38		
426.248	1.52	441.622	2.67		
426.597	1.45	441.666	2.67		
426.925	1.39	441.733	2.97		

[a]Time is in days since 00:00:00 - January 1, 1990; stage is in feet.

TABLE A.5 Digitized Stage of Prairie Creek at Western Patrol Road[a]

Time	Stage	Time	Stage	Time	Stage
150.610	1.22	167.235	1.15	183.871	1.23
150.779	1.22	167.579	1.14	184.200	1.21
151.136	1.22	167.936	1.14	184.555	1.19
151.460	1.21	168.247	1.14	184.877	1.17
151.818	1.20	168.618	1.13	185.246	1.16
152.108	1.19	168.928	1.10	185.561	1.14
152.432	1.20	169.286	1.10	185.883	1.13
152.803	1.20	169.610	1.08	186.218	1.11
153.100	1.20	169.927	1.08	186.553	1.10
153.477	1.18	170.304	1.10	186.915	1.09
153.781	1.17	170.595	1.11	187.224	1.08
154.132	1.16	170.932	1.26	187.566	1.08
154.490	1.14	171.296	1.21	187.901	1.07
154.800	1.15	171.593	1.15	188.223	1.07
155.171	1.14	171.971	1.24	188.585	1.06
155.495	1.13	172.281	1.17	188.900	1.05
155.832	1.15	172.619	1.33	189.242	1.04
156.170	1.15	173.233	1.92	189.564	1.03
156.493	1.15	173.611	1.75	189.885	1.02
156.878	1.16	173.934	1.58	190.268	1.07
157.175	1.15	174.258	1.47	190.556	1.06
157.519	1.13	174.629	1.39	190 885	1.05
157.843	1.14	174.953	1.34	191.240	1.07
158.173	1.13	175.345	1.31	191.535	1.19
158.524	1.47	175.601	1.26	191.910	1.18
158.700	3.62	175.510	1.26	192.205	1.18
159.125	2.57	175.805	1.23	192.554	1.16
159.489	2.12	176.160	1.21	192.896	1.12
159.813	1.92	176.469	1.21	193.198	1.09
160.197	1.80	176.851	1.19	193.587	1.07
160.508	1.67	177.173	1.19	193.888	1.08
160.845	1.58	177.528	1.17	194.224	1.07
161.223	1.53	177.863	1.16	194.579	1.07
161.527	1.46	178.185	1.19	194.887	1.07
161.904	1.41	178.554	1.17	195.270	1.07
162.195	1.37	178.862	1.15	195.565	1.06
162.539	1.37	179.211	1.16	195.907	1.05
162.903	1.31	179.513	1.75	196.249	1.04
163.220	1.29	179.828	2.10	196.570	1.04
163.571	1.26	180.170	2.03	196.926	1.03
163.888	1.24	180.478	1.81	197.234	1.02
164.219	1.25	180.834	1.66	197.563	1.00
164.563	1.27	181.203	1.55	197.918	1.00
164.880	1.25	181.518	1.48	198.206	0.99
165.251	1.24	181.893	1.40	198.595	0.97
165.561	1.21	182.202	1.36	198.904	0.97
165.892	1.19	182.550	1.32	199.246	0.97
166.243	1.18	182.885	1.29	199.594	0.96
166.540	1.17	183.194	1.27	199.896	0.95
166.931	1.16	183.583	1.26	200.271	1.04

TABLE A.5 (Cont'd)

Time	Stage	Time	Stage	Time	Stage
200.553	1.05	216.882	0.99	233.250	1.22
200.908	1.07	217.245	0.96	233.580	1.16
201.244	1.13	217.560	0.93	233.963	1.13
201.552	1.11	217.889	0.90	234.258	1.10
201.941	1.08	218.238	0.90	234.635	1.07
202.236	1.06	218.553	0.91	234.930	1.05
202.571	1.07	218.929	0.90	235.273	1.02
202.940	1.05	219.231	0.88	235.636	0.99
203.249	1.05	219.560	0.88	235.952	0.99
203.624	1.04	219.929	0.88	236.335	0.98
203.510	1.05	220.224	0.87	236.617	0.94
203.859	1.04	220.606	0.87	236.953	0.94
204.188	1.03	220.915	0.87	237.303	0.94
204.510	1.00	221.237	0.86	237.619	0.92
204.872	1.00	221.593	0.85	237.988	0.91
205.167	0.99	221.901	0.85	238.298	0.91
205.523	0.98	222.277	0.85	238.627	0.90
205.825	0.96	222.586	0.85	238.997	0.89
206.154	0.96	222.921	0.86	239.292	0.89
206.509	0.95	223.263	0.85	239.662	0.89
206.845	0.94	223.565	0.85	239.971	0.91
207.207	0.94	223.961	0.91	240.314	0.91
207.529	0.94	224.263	0.93	240.657	0.92
207.851	0.93	224.599	0.94	240.959	0.97
208.214	0.93	224.961	0.96	241.335	0.96
208.529	0.92	225.249	0.94	241.645	0.94
208.905	0.92	225.598	0.90	241.960	0.93
209.207	0.92	225.961	0.89	242.323	0.92
209.542	0.92	226.276	0.88	242.632	0.91
209.904	0.91	226.645	0.88	243.009	0.90
210.193	0.91	226.920	0.88	243.318	0.89
210.589	0.91	227.282	0.86	243.654	0.89
210.871	0.89	227.578	0.86	243.990	0.88
211.199	0.89	227.953	0.86	244.306	0.87
211.562	0.89	228.309	0.86	244.635	0.87
211.850	0.88	228.638	0.99	244.985	0.87
212.246	0.88	228.993	1.05	245.294	0.86
212.541	0.88	229.322	1.05	245.664	0.86
212.877	0.86	229.604	1.04	245.973	0.85
213.232	0.86	229.966	1.00	246.322	0.85
213.528	0.87	230.268	0.97	246.638	0.85
213.903	0.86	230.657	0.94	246.981	0.84
214.199	0.86	230.359	0.98	247.324	0.84
214.534	0.86	231.261	1.15	247.653	0.84
214.883	0.86	231.630	1.51	247.989	0.84
215.198	0.88	231.570	1.48	248.338	0.84
215.574	0.97	231.913	1.46	248.661	0.83
215.896	0.95	232.269	1.38	249.024	0.83
216.245	0.98	232.585	1.30	249.320	0.85
216.594	1.02	232.948	1.26	249.669	0.85

TABLE A.5 (Cont'd)

Time	Stage	Time	Stage	Time	Stage
250.019	0.85	266.166	0.83	283.112	2.41
250.348	0.84	266.481	0.81	283.420	2.15
250.684	0.84	266.822	0.82	283.801	1.95
251.007	0.83	267.478	0.81	284.116	1.80
251.363	0.83	267.845	0.82	284.450	1.69
251.679	0.83	268.153	0.82	284.798	1.59
252.015	0.83	268.474	0.80	285.112	1.52
252.371	0.82	268.849	0.82	285.474	1.45
252.694	0.82	269.143	0.82	285.781	1.40
253.023	0.82	269.518	0.81	286.109	1.36
253.332	0.83	269.819	0.82	286.470	1.32
253.661	0.83	270.147	0.82	286.771	1.32
254.031	0.83	270.488	0.82	287.146	1.30
254.327	0.83	270.796	0.84	287.467	1.27
254.683	0.82	271.197	0.85	287.802	1.24
255.026	0.83	271.492	0.85	288.136	1.23
255.342	0.82	271.813	0.86	288.451	1.21
255.711	0.83	272.174	0.86	288.799	1.20
256.014	0.83	272.468	0.84	289.120	1.19
256.370	0.82	272.809	0.85	289.481	1.18
256.692	0.83	273.144	0.85	289.822	1.18
257.015	0.84	273.458	0.83	290.130	1.25
257.378	0.83	273.820	0.83	290.478	1.37
257.694	0.82	274.127	0.83	290.792	1.51
258.016	0.82	274.448	0.82	291.133	1.44
258.359	0.82	274.796	0.83	295.490	1.10
258.688	0.81	275.117	0.82	295.778	1.10
259.065	0.81	275.485	0.82	296.140	1.08
259.367	0.81	275.800	0.88	296.441	1.08
259.710	0.81	276.121	0.92	296.769	1.08
260.053	0.82	276.469	0.91	297.124	1.07
260.389	0.81	276.790	0.89	297.445	1.05
260.590	0.81	277.145	0.87	297.793	1.05
260.540	0.80	277.446	0.85	298.101	1.04
260.801	0.81	277.787	0.88	298.430	1.03
261.129	0.82	278.135	0.88	298.791	1.03
261.450	0.83	278.462	0.86	299.106	1.02
261.798	0.83	278.804	0.86	299.494	1.03
262.146	0.83	279.125	0.86	299.796	1.03
262.460	0.82	279.493	0.85	300.117	1.00
262.835	0.82	279.814	0.86	300.445	1.00
263.142	0.82	280.148	0.87	300.793	1.00
263.457	0.83	280.510	0.87	301.155	0.99
263.825	0.87	280.811	0.90	301.456	0.99
264.139	0.88	281.138	1.00	301.798	1.00
264.527	0.86	281.486	0.99	302.146	0.99
264.802	0.84	281.801	1.29	302.467	1.00
265.136	0.83	282.155	1.83	302.815	1.00
265.497	0.83	282.443	2.33	303.123	0.99
265.798	0.83	282.798	2.59	303.451	0.99

TABLE A.5 (Cont'd)

Time	Stage	Time	Stage	Time	Stage
303.806	0.99	320.506	1.16	340.583	1.56
304.134	0.98	320.807	1.15	340.958	1.55
304.483	0.98	321.169	1.15	341.272	1.53
304.797	0.99	321.484	1.15	341.606	1.50
305.146	0.98	321.812	1.16	341.941	1.48
305.474	0.98	322.153	1.15	342.262	1.45
305.795	0.99	322.441	1.15	342.636	1.43
306.157	0.98	322.850	1.14	342.930	1.42
306.465	0.98	323.138	1.12	343.245	1.41
306.799	0.99	323.493	1.13	343.619	1.40
307.128	0.99	323.814	1.12	343.920	1.37
307.482	1.04	324.135	1.15	344.301	1.37
307.817	1.24	324.524	1.17	344.582	1.35
308.105	2.28	324.818	1.22	344.923	1.35
308.433	3.07	325.133	1.37	345.271	1.36
308.815	3.15	325.495	1.38	345.565	1.34
309.110	2.73	325.809	1.36	345.933	1.33
309.471	2.37	326.191	1.34	346.248	1.31
309.786	2.15	326.486	1.31	346.562	1.29
310.114	2.01	326.820	1.28	346.943	1.27
310.462	1.90	327.175	1.25	347.244	1.26
310.797	1.80	327.490	1.24	347.558	1.22
311.172	1.73	331.550	7.20	347.906	1.22
311.467	1.67	331.832	7.10	348.227	1.30
311.788	1.63	332.156	4.51	348.615	1.36
312.156	1.59	332.150	4.55	348.903	1.40
312.458	1.54	332.591	3.06	349.250	1.40
312.812	1.51	332.939	2.72	349.598	1.37
313.107	1.47	333.253	2.55	349.899	1.34
313.455	1.44	333.648	2.40	350.253	1.33
313.797	1.42	333.949	2.28	350.568	1.33
314.118	1.38	334.277	2.20	350.902	1.37
314.453	1.39	334.618	2.11	351.230	1.42
314.788	1.35	334.939	2.04	351.558	1.45
315.123	1.32	335.286	1.97	351.919	1.45
315.457	1.30	335.608	1.92	352.206	1.43
315.792	1.28	335.962	1.86	352.567	1.39
316.154	1.27	336.283	1.84	352.888	1.36
316.442	1.26	336.584	2.10	353.223	1.33
316.823	1.25	336.965	2.34	353.577	1.31
317.145	1.24	337.259	2.27	353.898	1.32
317.459	1.24	337.620	2.07	354.239	1.31
317.828	1.24	337.928	1.95	354.580	1.34
318.136	1.22	338.283	1.85	354.480	1.35
318.457	1.21	338.617	1.77	354.808	1.41
318.785	1.21	338.925	1.77	355.143	1.61
319.133	1.19	339.306	1.75	355.444	1.59
319.488	1.19	339.607	1.70	355.819	1.55
319.803	1.18	339.934	1.66	356.120	1.54
320.138	1.16	340.282	1.61	356.468	1.55

TABLE A.5 (Cont'd)

Time	Stage	Time	Stage	Time	Stage
356.776	1.54	373.495	1.55	398.791	0.72
357.124	1.54	373.823	1.55	399.100	0.72
357.485	1.54	374.165	1.55	399.443	0.72
357.807	1.54	374.493	1.55	399.806	0.73
358.188	1.54	374.821	1.55	400.095	0.82
358.483	1.54	375.162	1.55	400.425	1.01
358.817	1.54	375.497	1.55	400.781	2.22
359.179	1.55	375.851	1.55	401.036	2.86
359.493	1.54	376.139	1.55	401.446	2.39
359.861	1.54	376.494	1.55	401.762	2.23
360.162	1.54	376.835	1.55	402.098	2.41
360.497	1.54	377.163	1.55	402.435	2.17
360.852	1.54	377.531	1.55	402.784	1.91
361.160	1.54	377.819	1.55	403.134	1.81
361.535	1.54	378.167	1.55	403.443	1.70
361.836	1.54	378.502	0.69	403.772	1.61
362.164	1.54	378.843	0.60	404.135	1.60
362.518	1.54	379.205	0.60	404.438	1.61
362.833	1.55	379.499	0.60	404.828	1.58
363.201	1.55	379.874	0.60	405.117	1.69
363.496	1.55	380.195	0.60	405.446	1.66
363.824	1.55	380.516	0.60	405.803	1.55
364.192	1.55	380.885	0.59	406.132	1.49
364.506	1.55	381.139	0.59	406.482	1.44
364.874	1.55	381.520	0.59	406.797	1.39
365.176	1.55	381.868	0.60	407.140	1.35
365.497	1.55	382.176	0.60	407.463	1.34
365.858	1.55	382.524	0.60	407.792	1.32
366.160	1.55	382.859	0.60	408.169	1.31
366.508	1.55	383.187	0.60	408.471	1.31
366.836	1.55	383.548	0.60	408.807	1.31
367.157	1.55	383.856	0.60	409.157	1.32
367.532	1.55	384.218	0.60	409.460	1.47
367.806	1.55	384.539	0.60	409.829	1.40
368.174	1.55	384.900	0.60	410.125	1.32
368.489	1.55	385.228	0.60	410.481	1.32
368.830	1.55	385.556	0.60	410.818	1.32
369.178	1.55	385.898	0.60	411.133	1.32
369.486	1.55	386.259	0.60	411.517	1.32
369.814	1.55	386.534	0.60	411.819	1.32
370.162	1.55	395.470	0.70	412.155	1.32
370.490	1.55	395.752	0.71	412.505	1.32
370.838	1.55	396.075	0.71	412.794	1.32
371.153	1.55	396.451	0.71	413.184	1.32
371.487	1.55	396.741	0.71	413.473	1.31
371.855	1.55	397.104	0.71	413.762	1.47
372.157	1.55	397.426	0.71	414.145	2.05
372.511	1.55	397.749	0.71	414.481	2.16
372.819	1.55	398.119	0.72	414.831	1.95
373.141	1.55	398.441	0.72	415.154	1.71

TABLE A.5 (Cont'd)

Time	Stage	Time	Stage	Time	Stage
415.483	1.56	431.747	1.52	447.700	1.77
415.846	1.49	432.083	1.51	448.015	1.71
416.169	1.50	432.412	1.48	448.371	1.67
416.518	1.54	432.734	1.46	448.672	1.62
416.801	1.51	433.102	1.42	449.035	1.60
417.177	1.57	433.385	1.40	449.370	1.70
417.506	1.63	433.720	1.39	449.699	1.82
417.822	1.57	434.062	1.39	450.054	2.08
418.212	1.51	434.378	1.38	450.343	2.25
418.495	1.45	434.739	1.38	450.691	2.53
418.824	1.42	435.016	1.38	451.047	2.45
419.194	1.39	435.351	1.41	451.375	2.10
419.496	1.37	435.700	1.47	451.684	1.98
419.893	1.33	436.022	1.45		
420.189	1.31	436.370	2.39		
420.511	1.27	436.646	2.46		
420.861	1.26	436.982	2.46		
421.204	1.25	437.311	1.41		
421.574	1.24	437.646	1.46		
421.869	1.22	437.988	1.43		
422.192	1.22	438.290	1.43		
422.555	1.21	438.613	1.50		
422.891	1.21	438.955	1.58		
423.261	1.21	439.264	1.63		
423.543	1.20	439.632	2.02		
423.600	1.20	439.921	2.44		
423.916	1.20	440.263	2.53		
424.244	1.21	440.585	3.65		
424.567	1.26	440.930	4.05		
424.882	1.50	441.164	4.55		
425.165	2.64	441.505	5.20		
425.500	3.80	441.764	4.75		
425.796	3.98	441.916	4.05		
426.145	2.89	442.200	4.05		
426.520	2.38	442.274	3.50		
426.835	2.22	442.643	2.93		
427.204	1.98	442.991	2.75		
427.506	1.87	443.367	2.53		
427.815	1.82	443.669	2.35		
428.170	1.79	444.024	2.29		
428.466	1.74	444.346	2.20		
428.815	1.73	444.662	2.10		
429.143	1.79	445.044	2.00		
429.472	1.87	445.339	1.92		
429.821	1.88	445.674	1.86		
430.110	1.78	446.037	1.84		
430.452	1.69	446.365	1.87		
430.781	1.62	446.707	1.93		
431.110	1.58	447.016	1.90		
431.458	1.54	447.318	1.82		

[a]Time is in days since 00:00:00 - January 1, 1990; stage is in feet.

TABLE A.6 Stage of Prairie Creek at Northern Boundary of LAP

Time	Stage
176.00	2.78
204.00	2.30
232.00	2.20
261.00	1.70
296.00	2.40
345.00	2.75
352.00	2.70
424.00	2.32

[a]Time is in days since 00:00:00 = January 1, 1990; stage is in feet.

TABLE A.7 Groundwater Levels

Well No.	March 1990		April 1990		May 1990	
	TOC[a]	MSL[b]	TOC	MSL	TOC	MSL
MW101	5.48	551.45	6.07	550.86	5.82	551.11
MW102	4.34	533.74	5.39	532.69	5.63	532.45
MW103	NA[c]	5	7.45	533.89	7.14	534.20
MW104	5.07	544.05	6.72	542.40	6.03	543.09
MW105	4.48	550.68	5.72	549.44	5.33	549.83
MW106	2.28	539.68	3.10	538.86	2.86	539.10
MW107	4.71	547.92	5.86	546.77	5.70	546.93
MW108	5.56	538.24	7.15	536.65	6.56	537.24
MW109	4.13	529.67	6.40	527.40	4.59	529.21
MW110	4.96	529.15	5.67	528.43	5.34	528.76
MW111	5.46	526.42	6.80	525.08	6.28	525.60
MW112	4.80	529.53	5.33	529.00	4.65	529.68
MW113	4.31	532.01	5.38	530.95	4.78	531.55
MW114	3.92	551.78	10.73	544.96	10.50	545.19
MW115	5.19	528.70	6.13	527.75	5.62	528.26
MW116	4.02	531.62	5.30	530.34	4.79	530.85
MW117	4.06	526.09	4.85	525.30	4.67	525.48
MW118	3.50	530.49	3.67	530.32	3.52	530.47
MW119	5.19	534.50	6.28	533.41	5.75	533.94
MW120	29.47	557.71	29.45	557.73	29.21	557.97
MW121	13.65	561.84	7.38	568.11	13.44	562.05
MW122	3.68	536.17	5.17	534.67	4.85	534.99
MW123	3.61	532.23	3.80	532.04	3.67	532.17
MW124	5.14	531.43	5.49	531.08	5.58	530.99
MW125	10.00	555.88	10.89	554.99	10.21	555.67
MW126	20.78	544.12	21.07	543.83	20.72	544.18
MW127	4.10	599.38	4.86	598.63	5.00	598.49
MW128	4.88	616.89	5.65	616.12	5.49	616.28
MW129	5.70	558.35	6.94	557.11	6.31	557.74
MW130	3.27	525.13	4.37	524.03	3.79	524.61
MW131	12.12	611.23	8.39	614.96	11.44	611.91
MW132	4.56	601.87	5.73	600.70	5.51	600.92
MW133	4.56	596.76	5.00	596.32	5.00	596.32
MW134	5.50	608.17	6.33	607.34	6.06	607.61
MW135	4.44	630.83	4.86	630.41	4.86	630.41
MW136	5.39	597.58	6.68	596.29	6.78	596.19
MW137	1.21	632.42	4.74	628.89	4.77	628.86
MW138	15.15	610.53	15.33	610.35	15.07	610.61
MW139	8.04	637.24	9.89	635.39	8.97	636.31
MW140	9.69	572.72	10.94	571.47	10.24	572.17
MW141	5.13	562.44	6.22	561.34	5.81	561.75
MW142	6.18	610.09	6.55	609.71	6.42	609.84
MW143	5.38	633.35	5.78	632.95	5.77	632.96
MW144	5.44	636.18	7.80	633.82	6.34	635.28
MW145	7.63	634.72	8.37	633.98	8.35	634.00
MW146	6.23	612.92	6.47	612.68	6.41	612.74
MW147	NA	1	NA	1	NA	1
MW148	7.73	549.05	8.43	548.35	7.90	548.88
MW149	24.92	562.11	25.00	562.03	NA	
MW150	12.25	630.48	8.19	634.54	12.57	630.16
MW151	4.05	558.96	4.87	558.14	4.43	558.58
MW152	5.16	557.93	5.43	557.66	4.95	558.14
MW153	7.75	530.75	NA		6.79	531.71
MW154	8.03	525.08	8.50	524.61	8.48	524.63
MW155	10.23	519.39	13.37	516.25	10.49	519.13

TABLE A.7 (Cont'd)

Well No.	March 1990		April 1990		May 1990	
	TOC[a]	MSL[b]	TOC	MSL	TOC	MSL
MW156	7.78	534.35	7.62	534.51	7.84	534.29
MW157	4.33	530.46	4.68	530.11	4.44	530.35
MW158	3.82	531.01	4.05	530.78	3.98	530.85
MW159	NA	5	5.94	531.79	5.96	531.77
MW160	8.92	533.72	8.02	534.62	7.74	534.90
MW161	4.72	534.30	4.98	534.04	4.78	534.24
MW162	6.20	531.61	4.50	533.31	4.42	533.39
MW163	5.42	533.91	5.69	533.64	5.47	533.85
MW164	6.49	538.89	7.39	537.99	6.82	538.56
MW165	5.28	538.75	6.19	537.84	5.80	538.23
MW166	5.05	542.12	7.38	539.80	6.67	540.51
MW167	6.21	538.71	6.98	537.93	6.65	538.26
MW168	NA	5	11.31	502.62	10.76	503.17
MW169	NA	5	NA		6.08	505.48
MW170	NA	5	11.69	506.73	11.08	507.34
MW171	7.21	610.04	10.81	606.43	9.65	607.59
MW172	6.58	608.51	8.77	606.32	7.60	607.49
MW173	6.50	608.53	8.56	606.47	7.63	607.40
MW174	6.33	608.02	8.10	606.25	7.13	607.22
MW175	10.59	622.74	12.03	621.30	10.33	623.00
MW176	DRY		19.92	622.81	18.38	624.35
MW177	5.17	611.00	7.71	608.46	6.62	609.55
MW178	22.02	621.02	13.30	629.74	21.34	621.70
MW201	2.67	543.51	3.03	543.15	2.50	543.68
MW202	2.31	530.36	3.10	529.57	3.01	529.66
MW203	8.07	525.96	5.63	528.40	4.78	529.25
MW204	NA	5	3.89	521.64	NA	5
MW205	2.96	530.46	4.70	528.72	2.55	530.87
MW206	NA	5	4.20	529.57	NA	
MW207	9.75	545.84	9.86	545.73	9.70	545.89
MW208	3.64	533.95	4.46	533.13	3.35	534.24
MW209	2.24	534.38	2.95	533.67	2.80	533.82
MW210	11.30	555.75	11.52	555.53	10.95	556.10
MW211	15.46	553.54	15.66	553.34	15.26	553.74
MW212	16.65	551.91	15.85	552.71	15.44	553.12
MW213	22.35	544.03	22.82	543.56	22.01	544.37
MW214	24.22	543.28	14.63	552.87	23.90	543.60
MW215	24.37	543.85	24.80	543.42	24.09	544.13
MW216	6.37	532.68	6.50	532.55	6.36	532.69
MW217	6.48	532.64	6.56	532.56	6.05	533.07
MW218	31.46	562.58	31.60	562.44	31.21	562.83
MW219	7.80	532.49	4.80	535.49	4.04	536.25
MW220	2.79	537.53	3.82	536.50	3.17	537.15
MW221	2.92	537.33	3.36	536.89	2.96	537.29
MW222	5.16	535.87	5.82	535.21	5.49	535.54
MW223	2.65	604.48	4.89	602.24	3.93	603.20
MW224	2.43	604.09	2.69	603.83	2.92	603.60
MW225	5.81	609.32	6.76	608.37	6.67	608.46
MW226	4.38	607.18	5.26	606.29	5.33	606.22
MW227	4.88	616.85	4.15	617.57	4.10	617.62
MW228	3.99	620.00	5.35	618.64	5.42	618.57
MW229	6.54	617.72	7.00	617.26	6.99	617.27
MW230	3.98	615.65	4.13	615.50	4.13	615.50
MW231	0.96	549.08	1.30	548.74	1.48	548.56
MW232	5.30	530.05	6.29	529.06	5.94	529.41

TABLE A.7 (Cont'd)

Well No.	March 1990		April 1990		May 1990	
	TOC[a]	MSL[b]	TOC	MSL	TOC	MSL
MW233	4.57	530.50	5.50	529.57	4.96	530.11
MW234	3.63	529.82	4.61	528.84	4.18	529.27
MW235	3.19	530.06	4.63	528.62	4.03	529.22
1F3	5.10	-3.80	6.23	-4.93	NA	
26-9	NA	2,4	NA	2,4	NA	2,4
AEHA01	NA	4	28.93	4	28.28	4
AEHA08	NA	4,5	NA	4,5	NA	4,5
AEHA14	23.03	4	23.44	4	NA	4
AEHA15	24.29	4	24.75	4	NA	4
Farmwell	NA		23.60		NA	1,4
FW-6	NA	5	NA	4,5	NA	4,5
FW-63E	NA	5	NA	4,5	NA	4,5
FW-64E	NA	5	NA	4,5	NA	4,5
FW-65E	NA	5	NA	4,5	NA	4,5
FW-65-30	NA	5	NA	4,5	NA	4,5
G1	28.68		28.83		NA	
G1A	NA	4,5	NA	4,5	NA	4,5
G2	NA	4	32.61	4	NA	4
G2A	NA	4	27.72	4	NA	4
G3	NA	4	33.73	4	NA	4
G3A	NA	4	33.72	4	NA	4
GC 1	20.96	4	21.36	4	20.62	4
GC 3	20.56	4	20.96	4	20.22	4
GC 4	13.27	4	13.73	4	17.53	4
GC 4NW	NA	4	NA	4	13.07	4
GC 4SE	NA	4	NA	4	NA	4
GC 5		6		6	NA	6
GC 6	13.27	4	23.05	4	NA	4
M 1	23.48	4	23.98	4	23.10	4
M 2	24.96	4	25.72	4	24.71	4
M 3	19.03	4	19.56	4	18.67	4
Eastwell	NA	3	NA	3	NA	3
Westwell	NA	3	NA	3	NA	3
WSW-1	NA	2	NA	2	NA	2
WSW-2	290.00	241.80	290.00	241.80	290.00	241.80
WSW-3	NA	2	NA	2	NA	2
WSW-4	NA	2	NA	2	NA	2
WSW-5	NA	2	NA	2	NA	2
WSW-6	365.00	212.00	365.00	212.00	365.00	212.00
WSW-7	355.00	246.00	355.00	246.00	355.00	246.00
WSW-8	365.00	241.00	365.00	241.00	365.00	241.00
WSW-9	365.00	224.00	365.00	224.00	365.00	224.00
WSW-10	NA	2	NA	2	NA	2
WSW-11	NA	2	NA	2	NA	2
WSW-12	NA	2	NA	2	NA	2

Well No.	June 1990		July 1990		August 1990	
	TOC[a]	MSL[b]	TOC	MSL	TOC	MSL
MW101	5.96	550.97	5.98	550.95	5.09	551.84
MW102	10.15	527.93	11.24	526.84	6.53	531.55

TABLE A.7 (Cont'd)

Well No.	June 1990		July 1990		August 1990	
	TOC[a]	MSL[b]	TOC	MSL	TOC	MSL
MW103	8.42	532.92	8.97	532.37	7.52	533.82
MW104	6.67	542.45	NA	1	NA	1
MW105	5.85	549.31	6.55	548.61	5.89	549.27
MW106	3.76	538.20	4.25	537.71	4.42	537.48
MW107	6.65	545.98	6.74	545.89	5.79	546.84
MW108	8.18	535.62	8.85	534.95	9.09	534.71
MW109	7.44	526.36	7.77	526.03	6.11	527.69
MW110	6.60	527.50	7.07	527.03	6.69	527.41
MW111	7.38	524.50	8.02	523.86	8.65	523.23
MW112	5.80	528.53	6.81	527.52	4.37	529.96
MW113	6.32	530.01	7.19	529.14	5.28	531.05
MW114	10.78	544.91	10.99	544.70	9.97	545.72
MW115	6.60	527.28	7.14	526.74	7.03	526.85
MW116	6.11	529.53	7.18	528.46	5.12	530.52
MW117	5.21	524.94	5.51	524.64	4.25	525.90
MW118	3.75	530.24	3.75	530.24	3.47	530.52
MW119	6.63	533.06	6.78	532.91	5.45	534.24
MW120	29.61	557.57	29.77	557.41	29.60	557.58
MW121	14.92	560.57	14.07	561.42	13.84	561.65
MW122	5.43	534.41	5.45	534.39	4.46	535.38
MW123	3.98	531.86	4.18	531.66	3.54	532.30
MW124	5.55	531.02	5.60	530.97	4.88	531.69
MW125	11.08	554.80	11.37	554.51	11.32	554.56
MW126	21.95	542.95	22.07	542.83	21.65	543.25
MW127	7.51	595.98	8.29	595.20	7.52	595.97
MW128	6.33	615.44	6.53	615.24	5.48	616.29
MW129	7.47	556.58	9.04	555.01	7.10	556.95
MW130	5.21	523.19	6.44	521.96	6.71	521.69
MW131	14.95	608.40	16.13	607.22	16.78	606.57
MW132	6.41	600.02	7.26	599.17	6.61	599.82
MW133	5.58	595.74	6.10	595.22	5.61	595.71
MW134	6.61	607.06	7.07	606.60	6.08	607.59
MW135	5.50	629.77	6.98	628.29	5.27	630.00
MW136	9.45	593.52	10.13	592.84	9.27	593.70
MW137	15.29	618.34	18.26	615.37	14.49	619.14
MW138	16.01	609.67	16.55	609.13	16.46	609.22
MW139	9.91	635.37	10.66	634.62	10.84	634.44
MW140	10.70	571.71	10.93	571.49	9.97	572.44
MW141	5.98	561.58	6.46	561.10	5.11	562.45
MW142	6.48	609.78	7.02	609.24	6.47	609.79
MW143	.6.00	632.73	6.53	632.20	5.73	633.00
MW144	6.61	635.01	7.23	634.39	5.95	635.67
MW145	8.81	633.54	8.92	633.43	7.65	634.70
MW146	6.60	612.55	7.30	611.85	6.39	612.76
MW147	7.32	555.23	NA	1	NA	1
MW148	8.62	548.16	8.90	547.89	8.04	548.74
MW149	24.83	562.20	25.24	561.79	25.42	561.61
MW150	12.78	629.95	12.95	629.78	12.66	630.07
MW151	5.50	557.51	NA		NA	
MW152	5.81	557.28	6.21	556.88	5.76	557.33
MW153	7.58	530.92	8.47	530.03	8.25	530.25
MW154	8.89	524.22	9.12	523.99	8.56	524.55
MW155	8.14	521.48	11.91	517.71	11.64	517.98
MW156	7.77	534.36	7.77	534.36	7.29	534.84
MW157	4.55	530.24	NA	1	NA	1

TABLE A.7 (Cont'd)

Well No.	June 1990		July 1990		August 1990	
	TOC[a]	MSL[b]	TOC	MSL	TOC	MSL
MW158	4.22	530.61	4.47	530.36	3.90	530.93
MW159	6.07	531.66	NA	1	NA	1
MW160	8.32	534.32	8.45	534.19	8.38	534.26
MW161	5.18	533.84	5.12	533.90	4.57	534.45
MW162	4.77	533.04	NA	1	NA	1
MW163	5.78	533.55	5.92	533.41	5.52	533.81
MW164	7.06	538.32	7.24	538.14	6.63	538.75
MW165	6.61	537.42	7.07	536.96	6.23	537.80
MW166	8.10	539.08	8.54	538.64	4.81	542.37
MW167	7.56	537.35	7.89	537.02	7.00	537.91
MW168	11.52	502.41	11.56	502.37	11.33	502.60
MW169	6.89	504.67	7.16	504.40	6.36	505.20
MW170	13.12	505.30	13.67	504.75	13.20	505.22
MW171	10.98	606.26	NA	1	NA	1
MW172	9.32	605.77	10.00	605.09	9.73	605.36
MW173	9.33	605.70	NA	1	NA	1
MW174	8.75	605.60	9.45	604.90	9.36	604.99
MW175	16.87	616.46	NA	1	NA	1
MW176	21.86	620.87	NA	NA	NA	NA
MW177	8.84	607.33	NA	1	NA	1
MW178	24.80	618.24	26.71	616.33	30.28	612.76
MW201	3.49	542.69	3.94	542.24	NA g	NA
MW202	3.84	528.83	NA	1	NA	1
MW203	6.65	527.38	NA	1	NA	1
MW204	NA	5	NA	5	NA	5
MW205	4.07	529.35	5.00	528.42	2.59	530.83
MW206	5.52	528.25	7.86	525.91	9.37	524.40
MW207	9.69	545.90	9.86	545.73	9.00	546.59
MW208	5.00	532.59	5.00	532.59	3.45	534.14
MW209	3.92	532.70	4.20	532.42	2.48	534.14
MW210	11.75	555.30	NA	1	NA	1
MW211	15.81	553.19	15.91	553.09	15.91	553.09
MW212	14.70	553.86	NA	1	NA	1
MW213	22.82	543.56	NA	1	NA	1
MW214	24.77	542.73	24.98	542.52	24.25	543.25
MW215	24.82	543.40	25.06	543.16	24.32	543.90
MW216	6.65	532.40	NA	1	NA	1
MW217	6.84	532.28	7.09	532.03	6.87	532.25
MW218	31.57	562.47	31.84	562.20	31.93	562.11
MW219	5.39	534.90	NA	1	NA	1
MW220	4.36	535.96	NA	1	NA	1
MW221	3.92	536.33	4.40	535.85	2.89	537.36
MW222	6.23	534.80	6.70	534.33	5.35	535.68
MW223	4.64	602.49	NA	1	NA	1
MW224	3.29	603.23	NA	1	NA	1
MW225	7.73	607.40	7.71	607.42	7.52	607.61
MW226	5.52	606.03	5.51	606.04	4.05	607.50
MW227	4.34	617.38	5.04	616.68	5.46	616.26
MW228	5.75	618.24	NA	1	NA	1
MW229	7.24	617.02	NA	1	NA	1
MW230	4.17	615.46	4.26	615.37	3.43	616.20
MW231	2.08	547.96	NA	1	NA	1
MW232	6.68	528.67	7.45	527.90	6.59	528.76
MW233	5.89	529.18	NA	1	NA	1
MW234	4.68	528.77	NA	1	NA	1

TABLE A.7 (Cont'd)

Well No.	June 1990		July 1990		August 1990	
	TOC[a]	MSL[b]	TOC	MSL	TOC	MSL
MW235	4.77	528.48	4.96	528.29	NA	NA
1F3	7.03	-5.73	6.71	-5.41	2.91	-1.61
26-9	NA	2,4	NA	2,4	NA	2,4
AEHA01	29.50	4	3.57	4	31.23	4
AEHA08	NA	4,5	NA	4,5	NA	4,5
AEHA14	23.63	4	23.90	4	23.32	4
AEHA15	25.06	4	25.16	4	24.63	4
FARMWELL	NA	1,4	NA	1,4	NA	1,4
FW-6	NA	4,5		4,5	NA	4,5
FW-63E	NA	4,5		4,5	NA	4,5
FW-64E	NA	4,5		4,5	NA	4,5
FW-65E	NA	4,5		4,5	NA	4,5
FW-65-30	NA	4,5		4,5	NA	4,5
G1	29.82		NA		31.33	NA
G1A	NA	4,5	NA	4,5	NA	4,5
G2	28.41	4		4	30.09	4
G2A	28.61	4		4	30.20	4
G3	34.62	4		4	NA	4
G3A	34.75	4		4	NA	4
GC 1	21.63	4	21.99	4	22.92	4
GC 3	20.95	4	21.76	4	22.46	4
GC 4	14.18	4	NA	4	0.00	4
GC 4NW	NA	4	14.23	4	16.10	4
GC 4SE	NA	4	18.92	4	18.70	4
GC 5	NA	6	NA	6	NA	6
GC 6	NA	4	23.70	4	22.95	4
M 1	23.85	4	24.40	4	24.87	4
M 2	25.36	4	25.94	4	26.36	4
M 3	19.54	4	20.23	4	20.56	4
Eastwell	NA	3	NA	3	NA	3
Westwell	NA	3	NA	3	NA	3
WSW-1	NA	2	NA	2	NA	2
WSW-2	290.00	241.80	290.00	241.80	290.00	241.80
WSW-3	NA	2	NA	2	NA	2
WSW-4	NA	2	NA	2	NA	2
WSW-5	NA	2	NA	2	NA	2
WSW-6	365.00	212.00	365.00	212.00	365.00	212.00
WSW-7	355.00	246.00	355.00	246.00	355.00	246.00
WSW-8	365.00	241.00	NA	2	NA	2
WSW-9	365.00	224.00	365.00	224.00	365.00	224.00
WSW-10	NA	2	NA	2	NA	2
WSW-11	NA	2	NA	2	NA	2
WSW-12	NA	2	NA	2	NA	2

Well No.	September 1990		October 1990		November 1990	
	TOC[a]	MSL[b]	TOC	MSL	TOC	MSL
MW101	7.07	549.86	5.92	551.01	5.89	551.04
MW102	12.84	525.24	11.08	527.00	5.73	532.35
MW103	9.49	531.85	8.22	533.12	6.33	535.01
MW104	NA	1	NA	1	NA	1

TABLE A.7 (Cont'd)

Well No.	September 1990		October 1990		November 1990	
	TOC[a]	MSL[b]	TOC	MSL	TOC	MSL
MW105	8.73	546.43	6.57	548.59	4.55	550.61
MW106	5.05	536.91	4.16	537.80	2.63	539.33
MW107	7.52	545.11	NA		5.12	547.51
MW108	9.29	534.51	8.00	535.80	3.74	540.06
MW109	9.20	524.60	12.01	521.79	4.04	529.76
MW110	8.52	525.58	6.79	527.31	4.85	529.25
MW111	8.31	523.57	7.25	524.63	3.52	528.36
MW112	7.90	526.43	5.85	528.48	3.18	531.15
MW113	7.86	528.47	5.95	530.38	4.29	532.04
MW114	11.35	544.34	10.98	544.71	8.16	547.53
MW115	8.38	525.50	6.97	526.91	4.83	529.05
MW116	7.72	527.92	5.37	530.27	3.56	532.08
MW117	6.45	523.70	5.05	525.10	NA	
MW118	5.09	528.90	3.85	530.14	3.44	530.55
MW119	7.67	532.02	6.68	533.01	5.47	534.22
MW120	30.06	557.12	30.04	557.14	29.65	557.53
MW121	14.46	561.03	14.30	561.19	13.01	562.48
MW122	6.59	533.25	5.48	534.36	4.29	535.55
MW123	4.67	531.17	3.99	531.85	3.39	532.45
MW124	6.23	530.34	5.67	530.90	5.07	531.50
MW125	11.56	554.32	11.36	554.52	9.68	556.20
MW126	22.31	542.59	22.10	542.80	20.79	544.11
MW127	11.78	591.71	10.72	592.77	4.25	599.24
MW128	7.83	613.94	5.84	615.93	4.02	617.75
MW129	9.06	554.99	8.65	555.40	5.04	559.01
MW130	8.18	520.22	6.96	521.44	3.43	524.97
MW131	18.95	604.40	18.40	604.95	9.38	613.97
MW132	8.77	597.66	7.95	598.48	4.09	602.34
MW133	6.64	594.68	5.75	595.57	4.06	597.26
MW134	7.84	605.83	7.30	606.37	5.25	608.42
MW135	10.69	624.58	7.45	627.82	4.38	630.89
MW136	10.80	592.17	9.23	593.74	5.00	597.97
MW137	20.73	612.90	20.45	613.18	4.31	629.32
MW138	17.19	608.49	16.98	608.70	15.06	610.62
MW139	12.15	633.13	11.34	633.94	9.90	635.38
MW140	11.10	571.31	10.92	571.49	9.33	573.08
MW141	7.11	560.45	6.06	561.50	4.48	563.08
MW142	8.19	608.07	6.69	609.57	5.62	610.64
MW143	7.72	631.01	6.18	632.55	5.36	633.37
MW144	9.32	632.30	6.81	634.81	4.03	637.59
MW145	9.70	632.65	8.69	633.66	6.92	635.43
MW146	8.76	610.39	6.83	612.32	6.22	612.93
MW147	NA	1	NA	1	NA	1
MW148	9.11	547.67	8.65	548.13	7.16	549.62
MW149	25.47	561.56	25.69	561.34	25.56	561.47
MW150	13.46	629.27	12.95	629.78	11.87	630.86
MW151	7.28	555.73	6.31	556.70	NA	
MW152	7.64	555.45	6.80	556.29	NA	
MW153	9.49	529.01	8.08	530.42	NA	
MW154	9.29	523.82	8.75	524.36	6.00	527.11
MW155	13.80	515.82	11.73	517.89	9.59	520.03
MW156	8.16	533.97	7.93	534.20	6.55	535.58
MW157	NA	1	NA	1	NA	1
MW158	5.55	529.28	4.66	530.17	3.05	531.78

TABLE A.7 (Cont'd)

Well No.	September 1990		October 1990		November 1990	
	TOC[a]	MSL[b]	TOC	MSL	TOC	MSL
MW159	NA	1	NA	1	NA	1
MW160	8.91	533.73	8.31	534.33	7.58	535.06
MW161	5.39	533.63	4.96	534.06	NA	
MW162	NA	1	NA	1	NA	1
MW163	6.18	533.15	5.90	533.43	5.37	533.96
MW164	8.50	536.88	7.13	538.25	6.59	538.79
MW165	7.93	536.10	6.68	537.35	4.44	539.59
MW166	9.10	538.08	8.00	539.18	4.16	543.02
MW167	8.36	536.55	7.46	537.45	5.55	539.36
MW168	11.59	502.34	11.35	502.58	10.00	503.93
MW169	7.34	504.22	6.80	504.76	4.69	506.87
MW170	14.07	504.35	13.70	504.72	12.06	506.36
MW171	NA	1	NA	1	NA	1
MW172	10.94	604.15	10.37	604.72	11.02	604.07
MW173	NA	1	NA	1	NA	1
MW174	10.40	603.95	9.78	604.57	4.93	609.42
MW175	NA	1	NA	1	NA	1
MW176	DRY	NA	DRY	NA	15.75	626.98
MW177	NA	1	NA	1	NA	1
MW178	34.18	608.86	33.34	609.70	20.64	622.40
MW201	4.83	541.35	3.91	542.27	NA	
MW202	NA	1	NA	1	NA	1
MW203	NA	1	NA	1	NA	1
MW204	NA	5	NA	5	NA	5
MW205	5.62	527.80	3.60	529.82	2.40	531.02
MW206	9.47	524.30	5.62	528.15	2.37	531.40
MW207	10.19	545.40	9.76	545.83	8.34	547.25
MW208	5.35	532.24	4.39	533.20	NA	
MW209	4.80	531.82	3.33	533.29	2.34	534.28
MW210	NA	1	NA	1	NA	1
MW211	15.98	553.02	15.88	553.12	14.64	554.36
MW212	NA	1	NA	1	NA	1
MW213	NA	1	NA	1	NA	1
MW214	25.06	542.44	24.70	542.80	23.39	544.11
MW215	25.24	542.98	24.82	543.40	23.49	544.73
MW216	NA	1	NA	1	NA	1
MW217	8.66	530.46	7.63	531.49	5.85	533.27
MW218	32.06	561.98	32.16	561.88	31.93	562.11
MW219	NA	1	NA	1	NA	1
MW220	NA	1	NA	1	NA	1
MW221	5.50	534.75	4.22	536.03	2.42	537.83
MW222	7.72	533.31	6.40	534.63	4.93	536.10
MW223	NA	1	NA	1	NA	1
MW224	NA	1	NA	1	NA	1
MW225	8.00	607.13	6.85	608.28	6.39	608.74
MW226	6.57	604.98	5.69	605.86	4.10	607.45
MW227	5.56	616.16	5.20	616.52	4.75	616.97
MW228	NA	1	NA	1	NA	1
MW229	NA	1	NA	1	NA	1
MW230	4.49	615.14	4.45	615.18	3.38	616.25
MW231	NA	1	NA	1	NA	1
MW232	8.99	526.36	7.16	528.19	4.53	530.82
MW233	NA	1	NA	1	NA	1
MW234	NA	1	NA	1	NA	1
MW235	5.20	528.05	4.70	528.55	2.19	531.06

TABLE A.7 (Cont'd)

Well No.	September 1990		October 1990		November 1990	
	TOC[a]	MSL[b]	TOC	MSL	TOC	MSL
1F3	9.06	-7.76	5.75	-4.45	2.23	-0.93
26-9	NA	2,4	NA	2,4	NA	2,4
AEHA01	31.60	4	31.83	4	30.16	4
AEHA08	NA	4,5	NA	4,5	NA	4,5
AEHA14	23.97	4	23.69	4	22.60	4
AEHA15	25.30	4	25.08	4	24.23	4
FARMWELL	NA	1,4	NA	1,4	NA	1,4
FW-6	NA	4,5	NA	4,5	NA	4,5
FW-63E	NA	4,5	NA	4,5	NA	4,5
FW-64E	NA	4,5	NA	4,5	NA	4,5
FW-65E	NA	4,5	NA	4,5	NA	4,5
FW-65-30	NA	4,5	NA	4,5	NA	4,5
G1	31.69	NA	31.98	NA	30.06	NA
G1A	NA	4,5	NA	4,5	NA	4,5
G2	30.44	4	30.79	4	29.85	4
G2A	30.58	4	30.92	4	29.07	4
G3	NA	4	NA	4	34.91	4
G3A	NA	4	NA	4	35.25	4
GC 1	23.12	4	23.02	4	21.96	4
GC 3	22.72	4	22.72	4	21.69	4
GC 4	NA	4	NA	4	NA	4
GC 4NW	17.96	4	17.75	4	11.08	4
GC 4SE	19.48	4	19.30	4	17.78	4
GC 5	NA	6	NA	6	NA	6
GC 6	21.00	4	23.46	4	21.91	4
M 1	25.14	4	25.21	4	24.70	4
M 2	26.55	4	26.63	4	26.26	4
M 3	21.07	4	20.93	4	20.06	4
Eastwell	NA	3	NA	3	NA	3
Westwell	NA	3	368.90	274.72	NA	3
WSW-1	NA	2	NA	2	NA	2
WSW-2	290.00	241.80	290.00	241.80	290.00	241.80
WSW-3	NA	2	NA	2	NA	2
WSW-4	NA	2	NA	2	NA	2
WSW-5	NA	2	NA	2	NA	2
WSW-6	365.00	212.00	365.00	212.00	365.00	212.00
WSW-7	355.00	246.00	355.00	246.00	355.00	246.00
WSW-8	NA	2	NA	2	NA	2
WSW-9	365.00	224.00	365.00	224.00	365.00	224.00
WSW-10	NA	2	NA	2	NA	2
WSW-11	NA	2	NA	2	NA	2
WSW-12	NA	2	NA	2	NA	2

Well No.	December 1990 Week 1		December 1990 Week 2		December 1990 Week 3	
	TOC	MSL	TOC	MSL	TOC	MSL
MW101	11.18	545.75	6.68	550.25	6.78	550.15
MW102	5.98	532.10	7.10	530.98	6.85	531.23
MW103	6.70	534.64	6.96	534.38	NA	NA
MW104	NA	1	NA	1	NA	1

TABLE A.7 (Cont'd)

Well No.	December 1990 Week 1		December 1990 Week 2		December 1990 Week 3	
	TOC	MSL	TOC	MSL	TOC	MSL
MW105	4.92	550.24	5.61	549.55	5.54	549.62
MW106	2.56	539.40	3.10	538.86	3.08	538.88
MW107	5.50	547.13	6.96	545.67	5.25	547.38
MW108	5.62	538.18	6.52	537.28	6.78	537.02
MW109	4.29	529.51	NA		4.53	529.27
MW110	5.36	528.74	5.45	528.65	5.29	528.81
MW111	5.36	526.52	6.39	525.49	6.65	525.23
MW112	4.05	530.28	4.79	529.54	4.52	529.81
MW113	4.45	531.88	4.93	531.40	4.72	531.61
MW114	10.10	545.59	10.67	545.02	6.08	549.61
MW115	5.22	528.66	5.53	528.35	5.34	528.54
MW116	4.06	531.58	4.72	530.92	4.27	531.37
MW117	4.30	525.85	4.78	525.37	4.59	525.56
MW118	3.59	530.40	3.77	530.22	3.64	530.35
MW119	5.47	534.22	5.50	534.19	5.46	534.23
MW120	29.46	557.72	29.46	557.72	29.50	557.68
MW121	13.78	561.71	13.87	561.62	13.90	561.59
MW122	4.57	535.27	4.95	534.89	4.96	534.88
MW123	3.64	532.20	3.83	532.01	3.82	532.02
MW124	5.30	531.27	5.46	531.11	5.38	531.19
MW125	10.10	555.78	10.41	555.47	10.78	555.10
MW126	21.06	543.84	21.47	543.43	21.67	543.23
MW127	4.50	598.99	5.11	598.38	4.62	598.87
MW128	5.03	616.74	5.66	616.11	5.65	616.12
MW129	6.11	557.94	6.79	557.26	7.01	557.04
MW130	3.49	524.91	3.75	524.65	3.98	524.42
MW131	10.08	613.27	12.16	611.19	14.61	608.74
MW132	5.00	601.43	5.39	601.04	5.37	601.06
MW133	4.76	596.56	5.14	596.18	5.00	596.32
MW134	5.72	607.95	6.21	607.46	6.27	607.40
MW135	4.79	630.48	5.00	630.27	4.85	630.42
MW136	6.00	596.97	6.75	596.22	7.15	595.82
MW137	5.54	628.09	5.03	628.60	4.14	629.49
MW138	15.62	610.06	15.72	609.96	16.00	609.68
MW139	9.35	635.93	9.44	635.84	10.07	635.21
MW140	9.92	572.49	10.42	571.99	10.60	571.81
MW141	5.31	562.25	5.81	561.75	5.76	561.80
MW142	6.13	610.13	6.45	609.81	6.55	609.71
MW143	5.64	633.09	5.85	632.88	5.89	632.84
MW144	5.28	636.34	6.14	635.48	6.10	635.52
MW145	7.69	634.66	8.29	634.06	8.33	634.02
MW146	6.36	612.79	6.47	612.68	6.49	612.66
MW147	NA	1	NA	1	NA	1
MW148	7.86	548.32	8.50	548.28	8.60	548.18
MW149	25.15	561.88	24.90	562.13	24.88	562.15
MW150	11.90	630.83	7.10	635.63	12.27	630.46
MW151	3.86	559.15	4.19	558.82	NA	
MW152	4.67	558.42	5.02	558.07	NA	
MW153	6.65	531.85	6.89	531.61	6.91	531.59
MW154	8.38	524.73	8.72	524.39	8.73	524.38
MW155	10.49	519.13	11.84	517.78	10.87	518.75
MW156	7.67	534.46	7.84	534.29	7.76	534.37
MW157	NA	1	NA	1	NA	1
MW158	3.42	531.41	3.84	530.99	3.76	531.07

TABLE A.7 (Cont'd)

Well No.	December 1990 Week 1		December 1990 Week 2		December 1990 Week 3	
	TOC	MSL	TOC	MSL	TOC	MSL
MW159	NA	1	NA	1	NA	1
MW160	7.75	534.89	7.80	534.84	8.00	534.64
MW161	4.61	534.41	4.72	534.30	4.75	534.27
MW162	NA	1	NA	1	NA	1
MW163	5.59	533.74	5.67	533.66	5.71	533.62
MW164	6.71	538.67	6.86	538.52	6.83	538.55
MW165	5.21	538.82	5.64	538.39	5.61	538.42
MW166	5.80	541.38	7.16	540.02	7.27	539.91
MW167	6.56	538.35	7.00	537.91	7.14	537.77
MW168	10.60	503.33	10.64	503.29	11.04	502.89
MW169	5.51	506.05	6.29	505.27	6.45	505.11
MW170	12.51	505.91	11.62	506.80	12.81	505.61
MW171	NA	1	NA	1	NA	1
MW172	7.06	608.03	7.86	607.23	8.39	606.70
MW173	NA	1	NA	1	NA	1
MW174	6.66	607.69	7.46	606.89	8.05	606.30
MW175	NA	1	NA	1	NA	1
MW176	17.12	625.61	18.76	623.97	19.89	622.84
MW177	NA	1	NA	1	NA	1
MW178	20.93	622.11	22.36	620.68	24.71	618.33
MW201	NA		2.70	543.48	2.84	543.34
MW202	NA	1	NA	1	NA	1
MW203	NA	1	NA	1	NA	1
MW204	NA	5	NA	5	NA	5
MW205	2.71	530.71	2.82	530.60	2.97	530.45
MW206	2.92	530.85	2.80	530.97	3.12	530.65
MW207	9.51	546.08	9.85	545.74	9.92	545.67
MW208	3.08	534.51	3.32	534.27	3.50	534.09
MW209	2.60	534.02	2.65	533.97	2.46	534.16
MW210	NA	1	NA	1	NA	1
MW211	15.20	553.80	15.38	553.62	15.59	553.41
MW212	NA	1	NA	1	NA	1
MW213	NA	1	NA	1	NA	1
MW214	23.84	543.66	24.16	543.34	24.40	543.10
MW215	24.87	543.35	24.26	543.96	24.33	543.89
MW216	NA	1	NA	1	NA	1
MW217	6.07	533.05	6.38	532.74	6.22	532.90
MW218	31.64	562.40	31.42	562.62	31.54	562.50
MW219	NA	1	NA	1	NA	1
MW220	NA	1	NA	1	NA	1
MW221	2.76	537.49	3.14	537.11	3.04	537.21
MW222	5.21	535.82	5.46	535.57	5.45	535.58
MW223	NA	1	NA	1	NA	1
MW224	NA	1	NA	1	NA	1
MW225	6.06	609.07	6.43	608.70	6.67	608.46
MW226	5.00	606.55	5.28	606.27	5.33	606.22
MW227	4.59	617.13	4.69	617.03	4.70	617.02
MW228	NA	1	NA	1	NA	1
MW229	NA	1	NA	1	NA	1
MW230	4.05	615.58	4.19	615.44	4.12	615.51
MW231	NA	1	NA	1	NA	1
MW232	5.43	529.92	6.04	529.31	5.89	529.46
MW233	NA	1	NA	1	NA	1
MW234	NA	1	NA	1	NA	1

TABLE A.7 (Cont'd)

Well No.	December 1990 Week 1		December 1990 Week 2		December 1990 Week 3	
	TOC	MSL	TOC	MSL	TOC	MSL
MW235	2.95	530.30	3.15	530.10	3.17	530.08
1F3	3.82	-2.52	5.33	-4.03	5.52	-4.22
26-9	NA	2,4	NA	2,4	NA	2,4
AEHA01	29.36	4	29.00	4	28.94	4
AEHA08	NA	4,5	NA	4,5	NA	4,5
AEHA14	22.65	4	23.07	4	23.31	4
AEHA15	24.12	4	24.46	4	24.73	4
FARMWELL	NA	1,4	NA	1,4	NA	1,4
FW-6	NA	4,5	NA	4,5	NA	4,5
FW-63E	NA	4,5	NA	4,5	NA	4,5
FW-64E	NA	4,5	NA	4,5	NA	4,5
FW-65E	NA	4,5	NA	4,5	NA	4,5
FW-65-30	NA	4,5	NA	4,5	NA	4,5
G1	29.48	NA	28.95	NA	29.37	NA
G1A	NA	4,5	NA	4,5	NA	4,5
G2	28.28	4	27.71	4	28.20	4
G2A	28.42	4	27.88	4	28.36	4
G3	34.33	4	33.90	4	34.26	4
G3A	34.47	4	34.87	4	34.33	4
GC 1	21.33	4	21.31	4	21.42	4
GC 3	21.08	4	22.63	4	21.25	4
GC 4	NA	4	NA	4	NA	4
GC 4NW	12.46	4	13.11	4	13.47	4
GC 4SE	17.82	4	19.26	4	18.75	4
GC 5	NA	6	NA	6	NA	6
GC 6	22.43	4	22.90	4	23.27	4
M 1	24.05	4	23.78	4	23.81	4
M 2	25.50	4	25.33	4	25.32	4
M 3	19.23	4	19.39	4	19.52	4
Eastwell	NA	3	NA	3	NA	3
Westwell	NA	3	NA	3	NA	3
WSW-1	NA	2	NA	2	NA	2
WSW-2	290.00	241.80	290.00	241.80	290.00	241.80
WSW-3	NA	2	NA	2	NA	2
WSW-4	NA	2	NA	2	NA	2
WSW-5	NA	2	NA	2	NA	2
WSW-6	365.00	212.00	365.00	212.00	365.00	212.00
WSW-7	355.00	246.00	355.00	246.00	355.00	246.00
WSW-8	NA	2	NA	2	NA	2
WSW-9	365.00	224.00	365.00	224.00	365.00	224.00
WSW-10	NA	2	NA	2	NA	2
WSW-11	NA	2	NA	2	NA	2
WSW-12	NA	2	NA	2	NA	2

Well No.	January 1991		February 1991		March 1991	
	TOC	MSL	TOC	MSL	TOC	MSL
MW101	7.30	549.63	6.90	550.03	4.84	552.09
MW102	8.82	529.26	7.38	530.70	4.33	533.75
MW103	8.15	533.19	6.90	534.44	6.20	535.14

TABLE A.7 (Cont'd)

Well No.	January 1991 TOC	January 1991 MSL	February 1991 TOC	February 1991 MSL	March 1991 TOC	March 1991 MSL
MW104	NA	1	NA	1	NA	1
MW105	6.62	548.54	6.19	548.97	4.84	550.32
MW106	3.71	538.25	3.42	538.54	2.10	539.86
MW107	6.82	545.81	6.30	546.33	5.31	547.32
MW108	7.90	535.90	7.27	536.53	5.77	538.03
MW109	6.67	527.13	4.41	529.39	4.47	529.33
MW110	6.70	527.40	5.61	528.49	4.98	529.12
MW111	7.18	524.70	6.90	524.98	5.90	525.98
MW112	5.91	528.42	5.23	529.10	3.78	530.55
MW113	6.39	529.94	5.21	531.12	4.26	532.07
MW114	11.44	544.25	11.13	544.56	10.54	545.15
MW115	6.27	527.61	5.76	528.12	5.06	528.82
MW116	5.83	529.81	4.89	530.75	3.79	531.85
MW117	5.77	524.38	4.89	525.26	4.29	525.86
MW118	3.81	530.18	3.65	530.34	3.58	530.41
MW119	7.25	532.44	5.89	533.80	5.47	534.22
MW120	29.52	557.66	29.44	557.74	28.37	558.81
MW121	14.14	561.35	13.85	561.64	12.98	562.51
MW122	5.78	534.06	5.27	534.57	4.42	535.42
MW123	4.26	531.58	4.03	531.81	3.57	532.27
MW124	5.88	530.69	5.74	530.83	5.02	531.55
MW125	11.13	554.75	9.36	556.52	9.87	556.01
MW126	22.40	542.50	22.60	542.30	20.99	543.91
MW127	5.74	597.75	5.02	598.47	3.92	599.57
MW128	6.15	615.62	5.53	616.24	4.74	617.03
MW129	7.77	556.28	7.29	556.76	4.60	559.45
MW130	5.05	523.35	3.75	524.65	3.26	525.14
MW131	15.12	608.23	14.30	609.05	5.92	617.43
MW132	6.45	599.98	5.95	600.48	3.85	602.58
MW133	5.45	595.87	5.20	596.12	3.78	597.54
MW134	6.71	606.96	6.38	607.29	4.75	608.92
MW135	5.98	629.29	5.30	629.97	4.34	630.93
MW136	7.75	595.22	6.95	596.02	4.39	598.58
MW137	4.65	628.98	4.50	629.13	3.98	629.65
MW138	15.99	609.69	15.80	609.88	13.20	612.48
MW139	11.10	634.18	10.56	634.72	8.05	637.23
MW140	11.02	571.39	11.01	571.40	9.56	572.85
MW141	6.27	561.29	6.17	561.39	4.38	563.18
MW142	6.97	609.29	6.82	609.44	5.25	611.01
MW143	6.23	632.50	5.93	632.80	4.66	634.07
MW144	7.18	634.44	6.97	634.65	4.14	637.48
MW145	9.00	633.35	8.52	633.83	7.03	635.32
MW146	6.80	612.35	6.59	612.56	6.09	613.06
MW147	NA	1	NA	1	NA	1
MW148	8.99	547.79	8.47	548.31	7.60	549.18
MW149	25.01	562.02	24.85	562.18	23.88	563.15
MW150	13.24	629.49	12.91	629.82	12.20	630.53
MW151	5.81	557.20	4.54	558.47	3.02	559.99
MW152	6.16	556.93	5.44	557.65	3.80	559.29
MW153	6.92	531.58	7.06	531.44	6.75	531.75
MW154	9.17	523.94	8.90	524.21	8.40	524.71
MW155	11.97	517.65	11.16	518.46	11.15	518.47
MW156	8.11	534.02	8.07	534.06	7.70	534.43
MW157	NA	1	NA	1	NA	1
MW158	4.57	530.26	4.15	530.68	3.26	531.57

TABLE A.7 (Cont'd)

Well No.	January 1991		February 1991		March 1991	
	TOC	MSL	TOC	MSL	TOC	MSL
MW159	NA	1	NA	1	NA	1
MW160	8.30	534.34	8.11	534.53	2.56	540.08
MW161	NA	NA	4.79	534.23	4.75	534.27
MW162	NA	1	NA	1	NA	1
MW163	6.23	533.10	5.95	533.38	5.31	534.02
MW164	7.23	538.15	6.90	538.48	6.41	538.97
MW165	6.85	537.18	9.53	534.50	4.94	539.09
MW166	8.36	538.82	7.60	539.58	4.85	542.33
MW167	7.54	537.37	7.33	537.58	6.67	538.24
MW168	NA	NA	8.98	504.95	10.70	503.23
MW169	7.10	504.46	6.51	505.05	4.59	506.97
MW170	13.12	505.30	12.58	505.84	10.96	507.46
MW171	NA	1	NA	1	NA	1
MW172	9.21	605.88	8.91	606.18	5.33	609.76
MW173	NA	1	NA	1	NA	1
MW174	8.73	605.62	8.26	606.09	5.15	609.20
MW175	NA	1	NA	1	NA	1
MW176	22.58	620.15	21.48	621.25	12.13	630.60
MW177	NA	1	NA	1	NA	1
MW178	25.50	617.54	24.33	618.71	17.01	626.03
MW201	3.61	542.57	3.30	542.88	In Pond	
MW202	NA	1	NA	1	NA	1
MW203	NA	1	NA	1	NA	1
MW204	NA	5	NA	5	NA	5
MW205	4.13	529.29	3.46	529.96	2.47	530.95
MW206	4.43	529.34	3.30	530.47	2.46	531.31
MW207	10.21	545.38	10.17	545.42	9.75	545.84
MW208	5.19	532.40	4.15	533.44	3.25	534.34
MW209	4.17	532.45	2.79	533.83	2.34	534.23
MW210	NA	1	NA	1	NA	1
MW211	15.82	553.18	15.46	553.54	15.14	553.86
MW212	NA	1	NA	1	NA	1
MW213	NA	1	NA	1	NA	1
MW214	24.88	542.62	24.90	542.60	23.82	543.68
MW215	24.97	543.25	25.02	543.20	23.92	544.30
MW216	NA	1	NA	1	NA	1
MW217	7.10	532.02	6.62	532.50	5.97	533.15
MW218	31.55	562.49	31.50	562.54	30.46	563.58
MW219	NA	1	NA	1	NA	1
MW220	NA	1	NA	1	NA	1
MW221	4.62	535.63	3.36	536.89	2.72	537.53
MW222	6.70	534.33	5.66	535.37	5.05	535.98
MW223	NA	1	NA	1	NA	1
MW224	NA	1	NA	1	NA	1
MW225	7.47	607.66	7.26	607.87	6.21	608.92
MW226	5.94	605.61	5.33	606.22	3.93	607.62
MW227	5.12	616.60	4.50	617.22	4.16	617.56
MW228	NA	1	NA	1	NA	1
MW229	NA	1	NA	1	NA	1
MW230	4.35	615.28	4.21	615.42	3.35	616.28
MW231	NA	1	NA	1	NA	1
MW232	6.78	528.57	6.41	528.94	5.34	530.01
MW233	NA	1	NA	1	NA	1
MW234	NA	1	NA	1	NA	1
MW235	3.75	529.50	3.37	529.88	2.92	530.33

TABLE A.7 (Cont'd)

Well No.	January 1991		February 1991		March 1991	
	TOC	MSL	TOC	MSL	TOC	MSL
1F3	8.60	-7.30	6.63	-5.33	2.63	-1.33
26-9	NA	2,4	NA	2,4	NA	2,4
AEHA01	29.09	4	27.44	4	27.46	4
AEHA08	NA	4,5	NA	4,5	NA	4,5
AEHA14	23.95	4	24.01	4	22.86	4
AEHA15	25.34	4	25.43	4	24.37	4
FARMWELL	NA	1,4	NA	1,4	NA	1,4
FW-6	NA	4,5	NA	4,5	NA	4,5
FW-63E	NA	4,5	NA	4,5	NA	4,5
FW-64E	NA	4,5	NA	4,5	NA	4,5
FW-65E	NA	4,5	NA	4,5	NA	4,5
FW-65-30	NA	4,5	NA	4,5	NA	4,5
G1	29.30	NA	29.35	NA	26.97	NA
G1A	NA	4,5	NA	4,5	NA	4,5
G2	28.14	4	28.24	4	25.83	4
G2A	28.30	4	28.28	4	26.04	4
G3	34.20	4	34.36	4	31.91	4
G3A	34.30	4	34.34	4	32.06	4
GC 1	21.75	4	21.75	4	20.56	4
GC 3	22.52	4	21.56	4	20.40	4
GC 4	NA	4	NA	4	NA	4
GC 4NW	13.95	4	13.38	4	12.82	4
GC 4SE	19.41	4	18.90	4	17.62	4
GC 5	NA	?	NA	?	NA	?
GC 6	23.74	4	23.70	4	22.47	4
M 1	24.31	4	24.31	4	18.69	4
M 2	25.78	4	25.75	4	25.00	4
M 3	19.97	4	19.94	4	18.70	4
Eastwell	NA	3	NA	3	NA	3
Westwell	NA	3	NA	3	NA	3
WSW-1	NA	2	NA	2	NA	2
WSW-2	290.00	241.80	290.00	241.80	290.00	241.80
WSW-3	NA	2	NA	2	NA	2
WSW-4	NA	2	NA	2	NA	2
WSW-5	NA	2	NA	2	NA	2
WSW-6	365.00	212.00	365.00	212.00	365.00	212.00
WSW-7	355.00	246.00	355.00	246.00	355.00	246.00
WSW-8	NA	2	NA	2	NA	2
WSW-9	365.00	224.00	365.00	224.00	365.00	224.00
WSW-10	NA	2	NA	2	NA	2
WSW-11	NA	2	NA	2	NA	2
WSW-12	NA	2	NA	2	NA	2

[a]TOC is depth to water in feet measured from top of well casing.

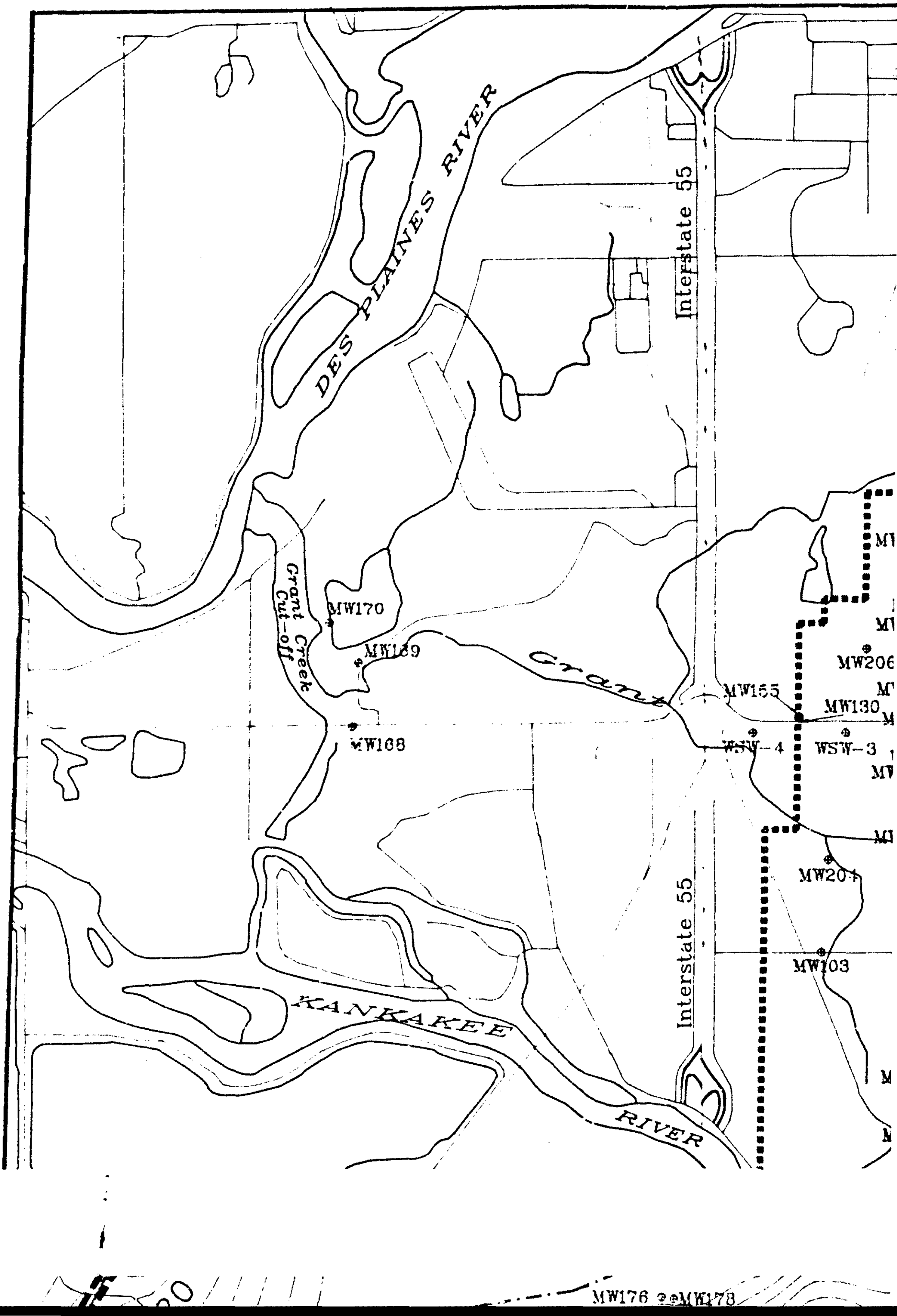
[b]MSL is elevation of water in feet above mean sea level.

[c]NA means data are not available.

TABLE A.7 (Cont'd)

Notes:

1. Removed from monitoring list during optimization.
2. Data from deep production wells are recorded by site personnel.
3. Data from these wells are obtained when they are accessible.
4. Geologic logs and elevation data are not available.
5. Location is uncertain.
6. Conflicts exist between field labels of wells and map labels.
7. Elevation reported; position calculated from Illinois State Water Survey (ISWS) Bulletin No. 34 (1941) and ISWS Bulletin No. 41 (1943).
8. Elevation is from ISWS (personal communication, 1991); position is calculated from well identification.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Grant Creek Cut-off
MW170
MW169
MW168
Grant
MW155
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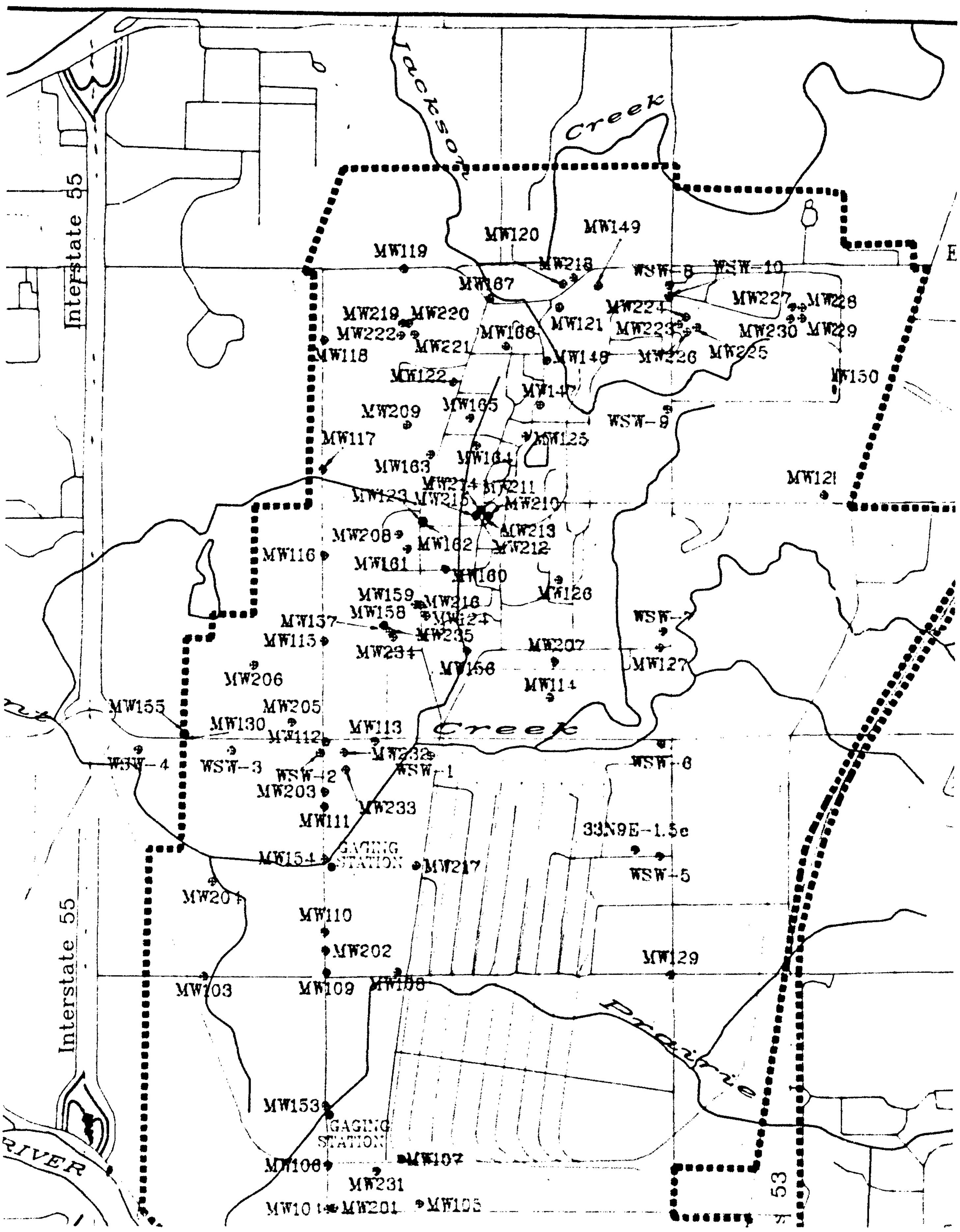
MW206
WSW-4
WSW-3
MW204
MW103
KANKAKEE
RIVER
Interstate 55
MW176
MW178


Interstate 55
Jackson
Creek
Creek
Prairie
RIVER
53
E
MW119
MW120
MW149
MW218
WSW-8
WSW-10
MW167
MW224
MW227
MW228
MW219
MW220
MW121
MW223
MW230
MW229
MW222
MW166
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MW118
MW148
MW226
MW225
MW122
MW147
MW150
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WSW-9
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WSW-3
WSW-2
WSW-1
WSW-6
MW203
MW233
MW111
33N9E-1.5c
MW154
GAGING STATION
MW217
WSW-5
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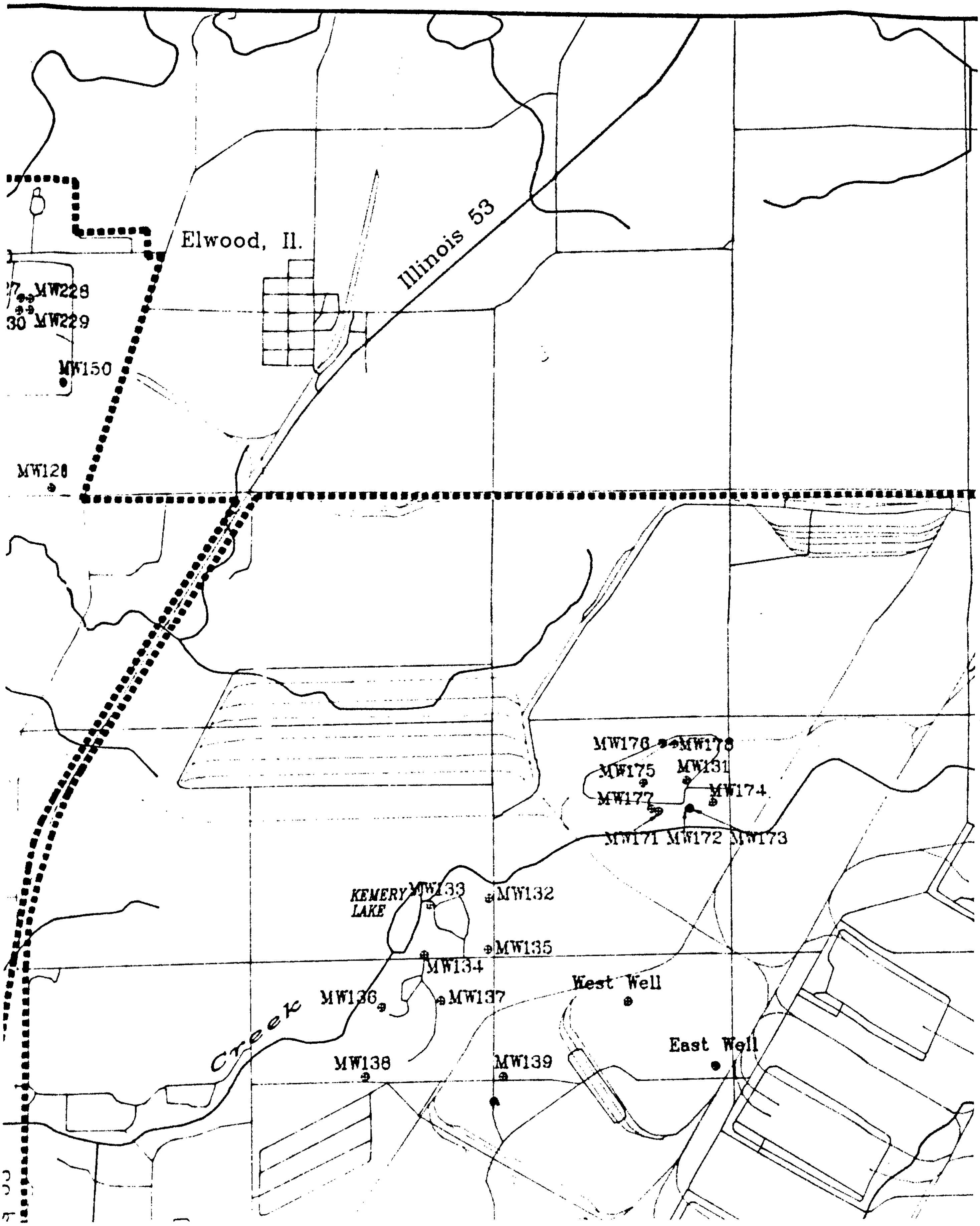
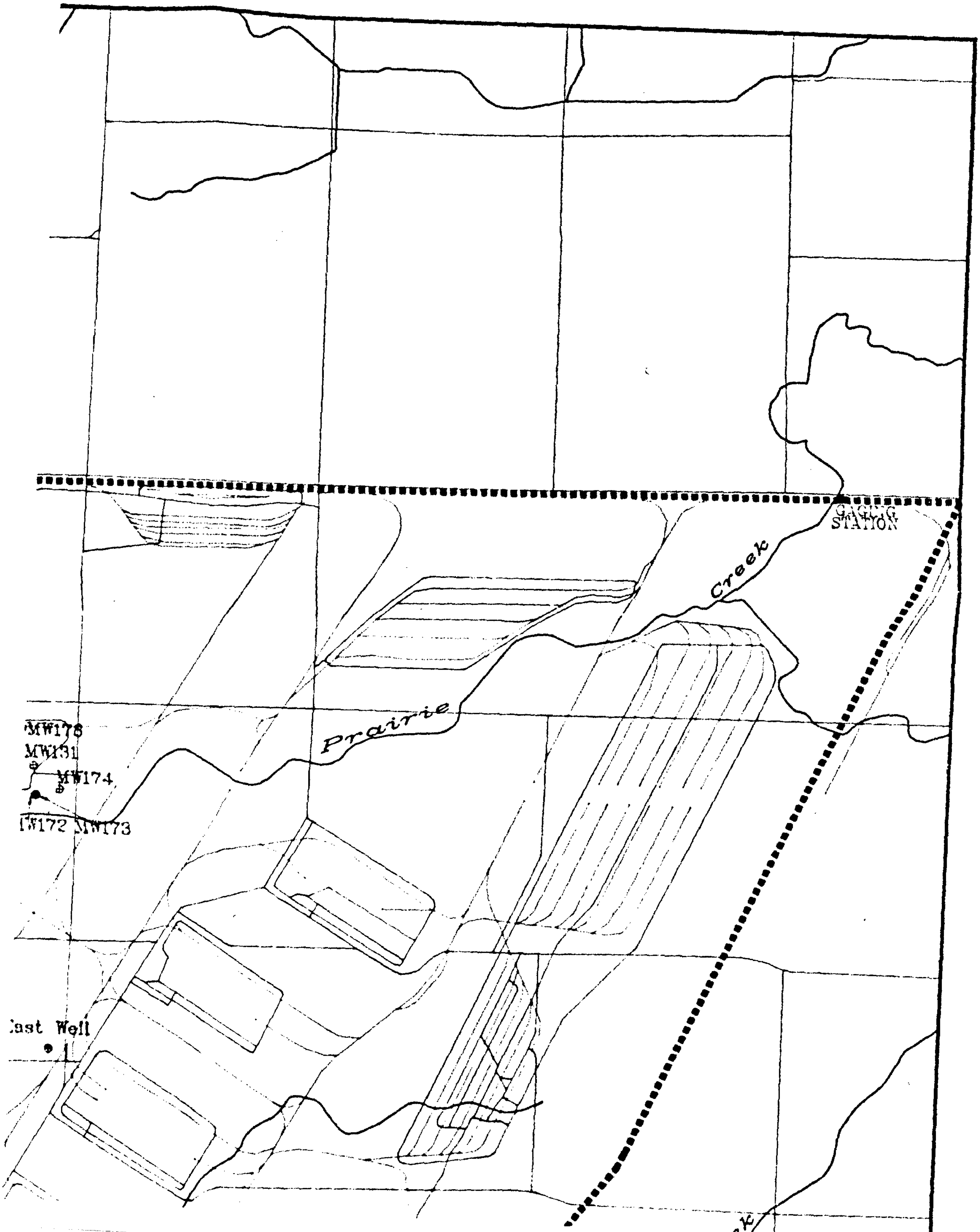
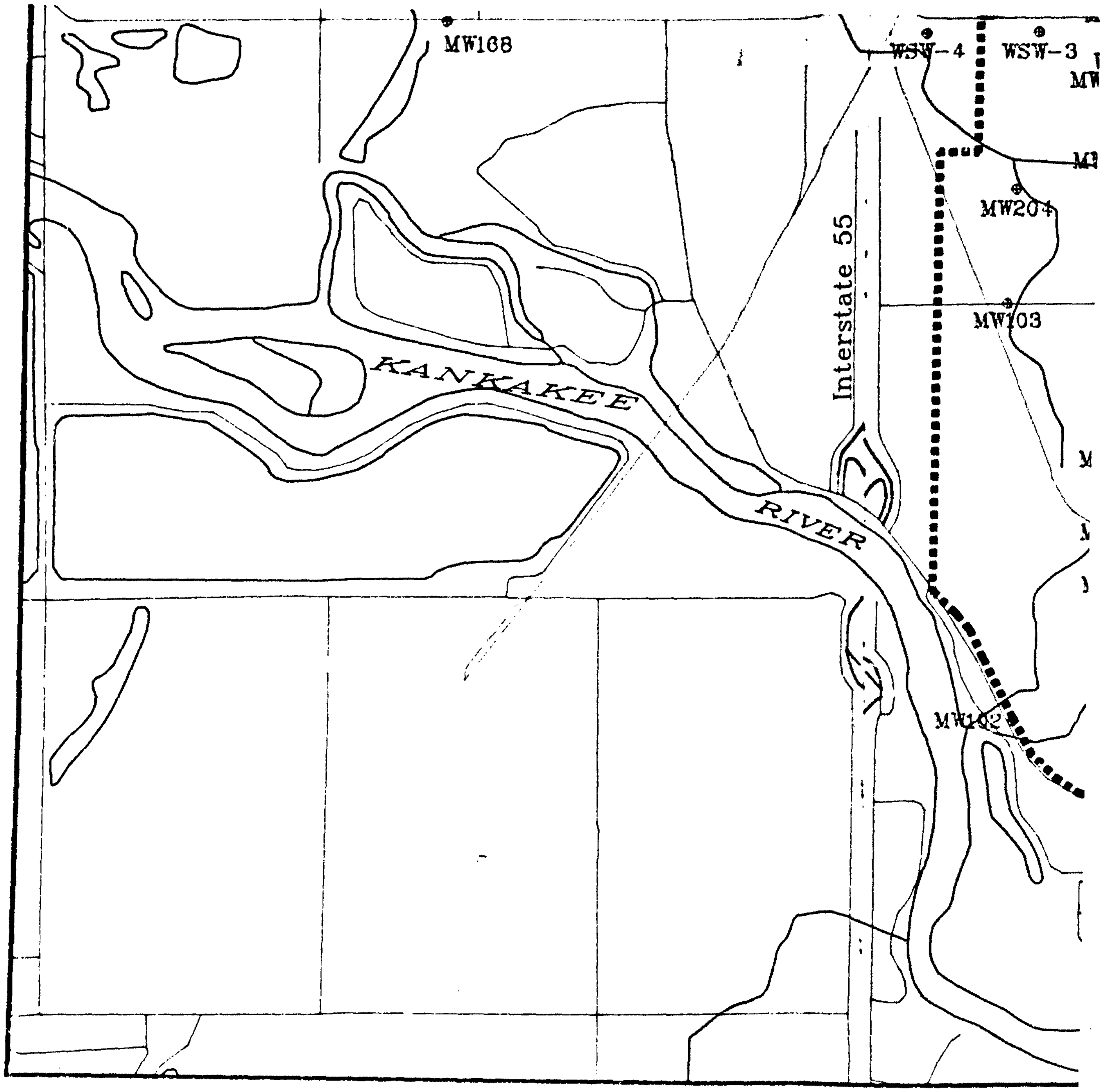
MW107
MW231
MW201
MW105



Elwood, Il.
Illinois 53
MW228
MW229
30
MW150
MW128
MW176
MW178
MW175
MW131
MW174
MW177
MW171
MW172
MW173
KEMERY LAKE
MW133
MW132
MW135
MW134
MW136
MW137
West Well
East Well
MW138
MW139
Creek



GAGING
STATION
Creek
Prairie
MW178
MW131
MW174
W172
MW173
ast Well
1



LEGEND

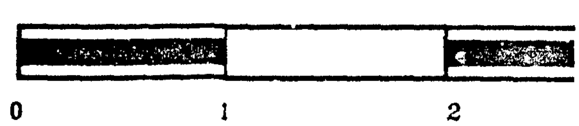
Facility Boundary

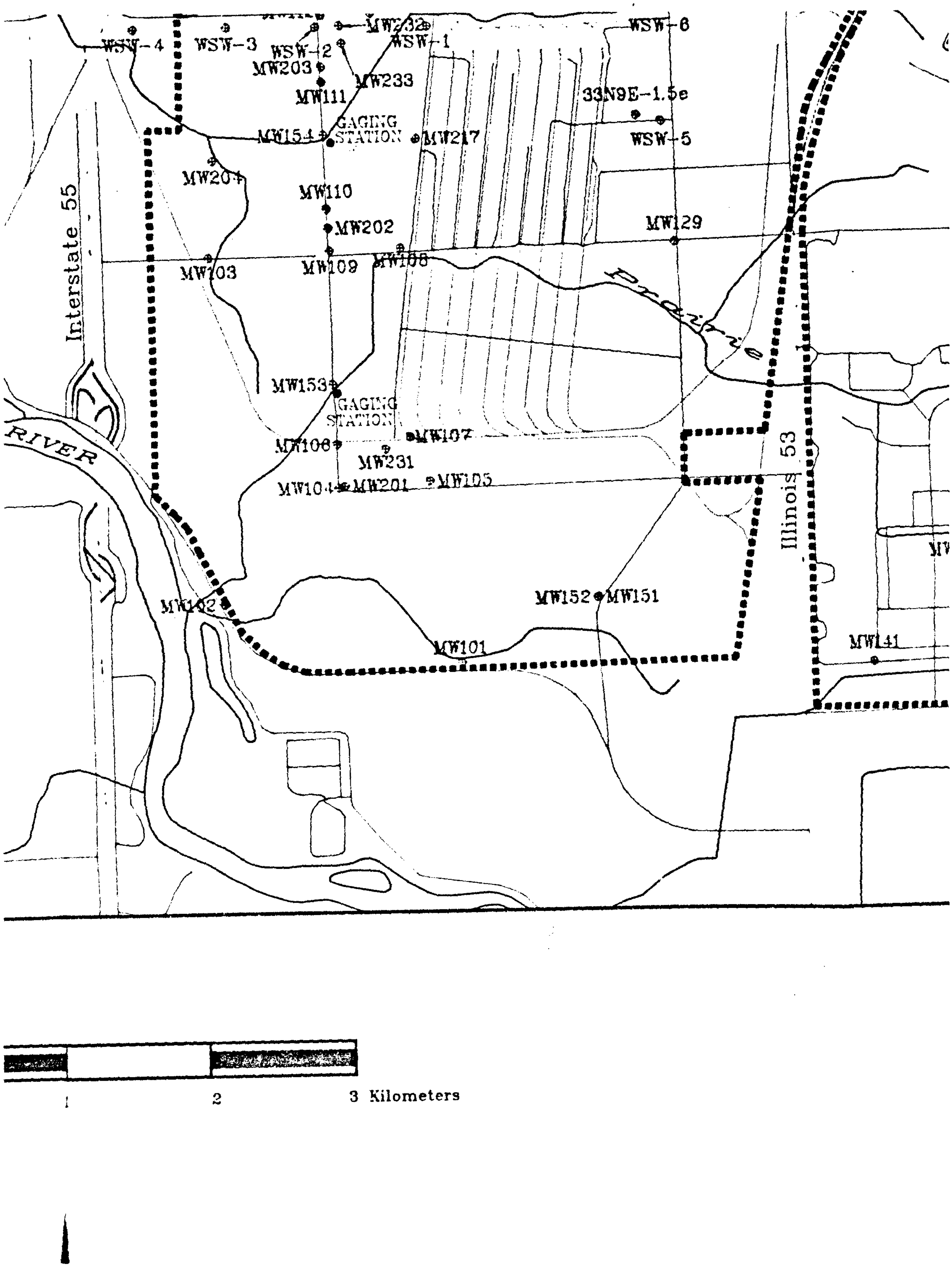
Railroad

Divided Highway

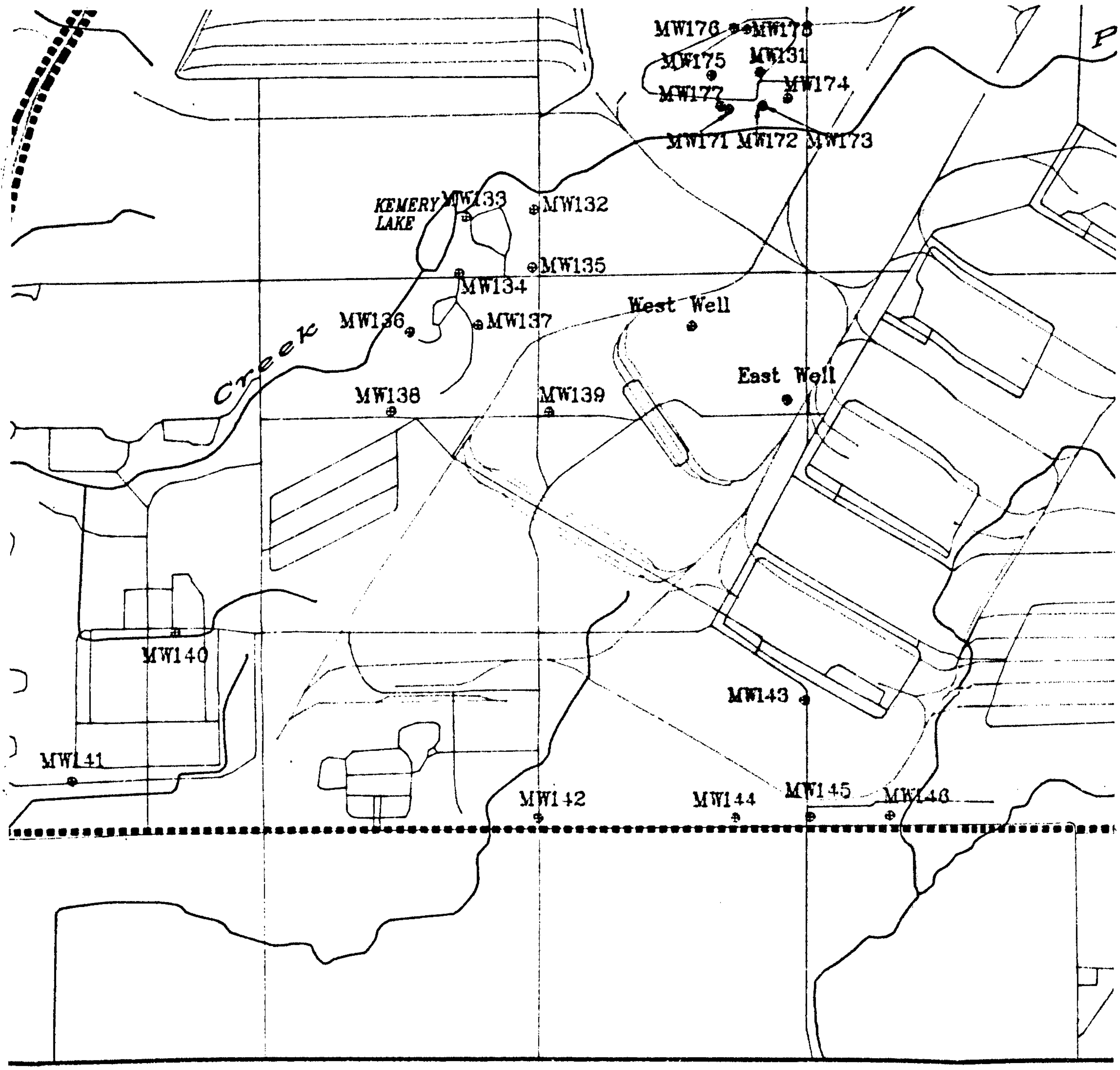
MW101 Monitoring Well

Surface Water





WSW-4
WSW-3
WSW-2
MW232
WSW-1
WSW-6
MW203
MW233
MW111
33N9E-1.5e
MW154
GAGING STATION
MW217
WSW-5
MW204
MW110
MW202
MW129
Interstate 55
MW103
MW109
MW108
Prairie
MW153
GAGING STATION
RIVER
MW106
MW107
MW231
Illinois 53
MW104
MW201
MW105
MW152
MW151
MW102
MW101
MW141
1
2
3 Kilometers


MW176
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MW131
MW174
MW177
MW171
MW172
MW173
KEMERY LAKE
MW133
MW132
MW135
MW134
Creek
MW136
MW137
West Well
East Well
MW138
MW139
MW140
MW143
MW141
MW142
MW144
MW145
MW146

Jc

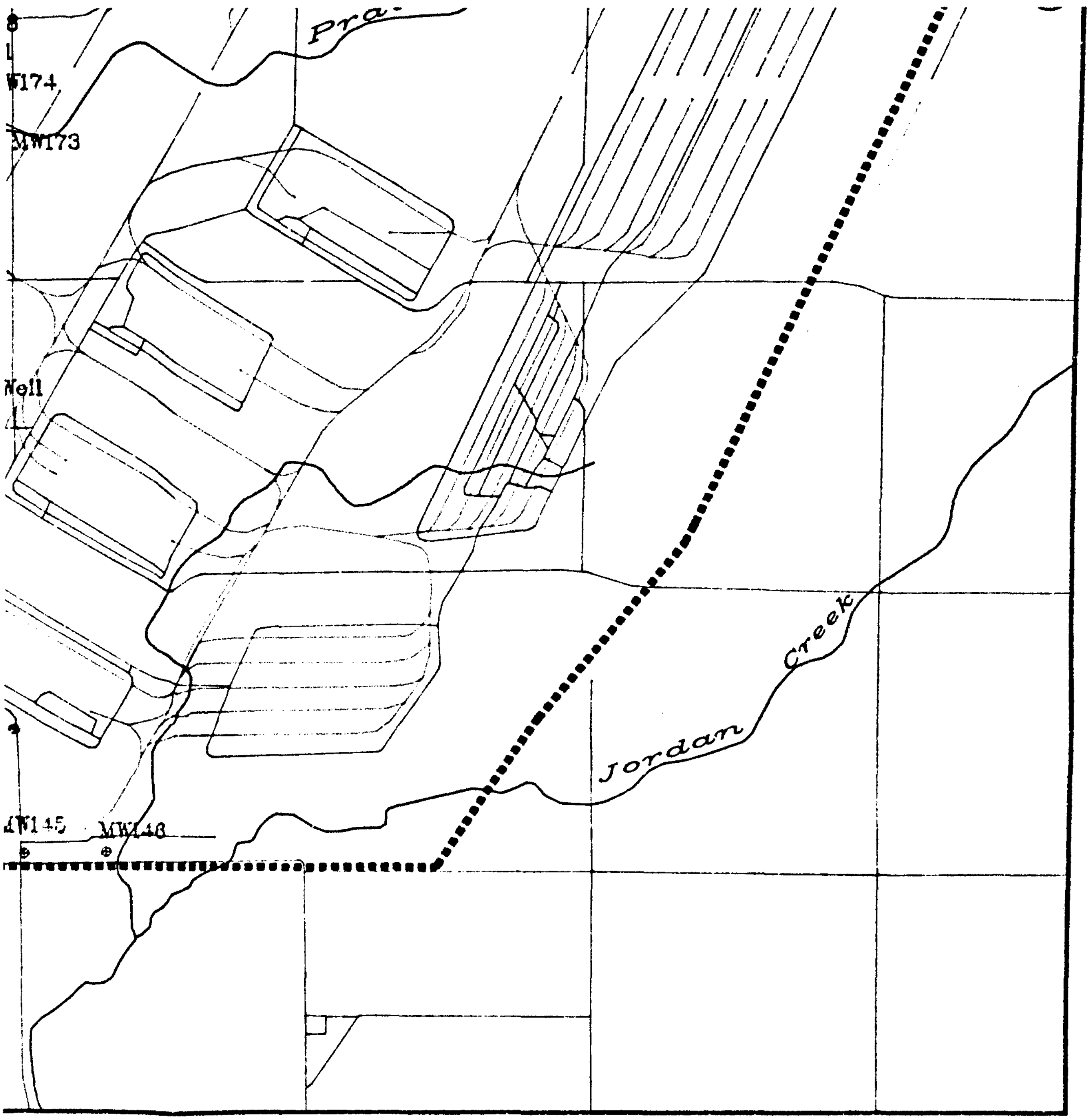
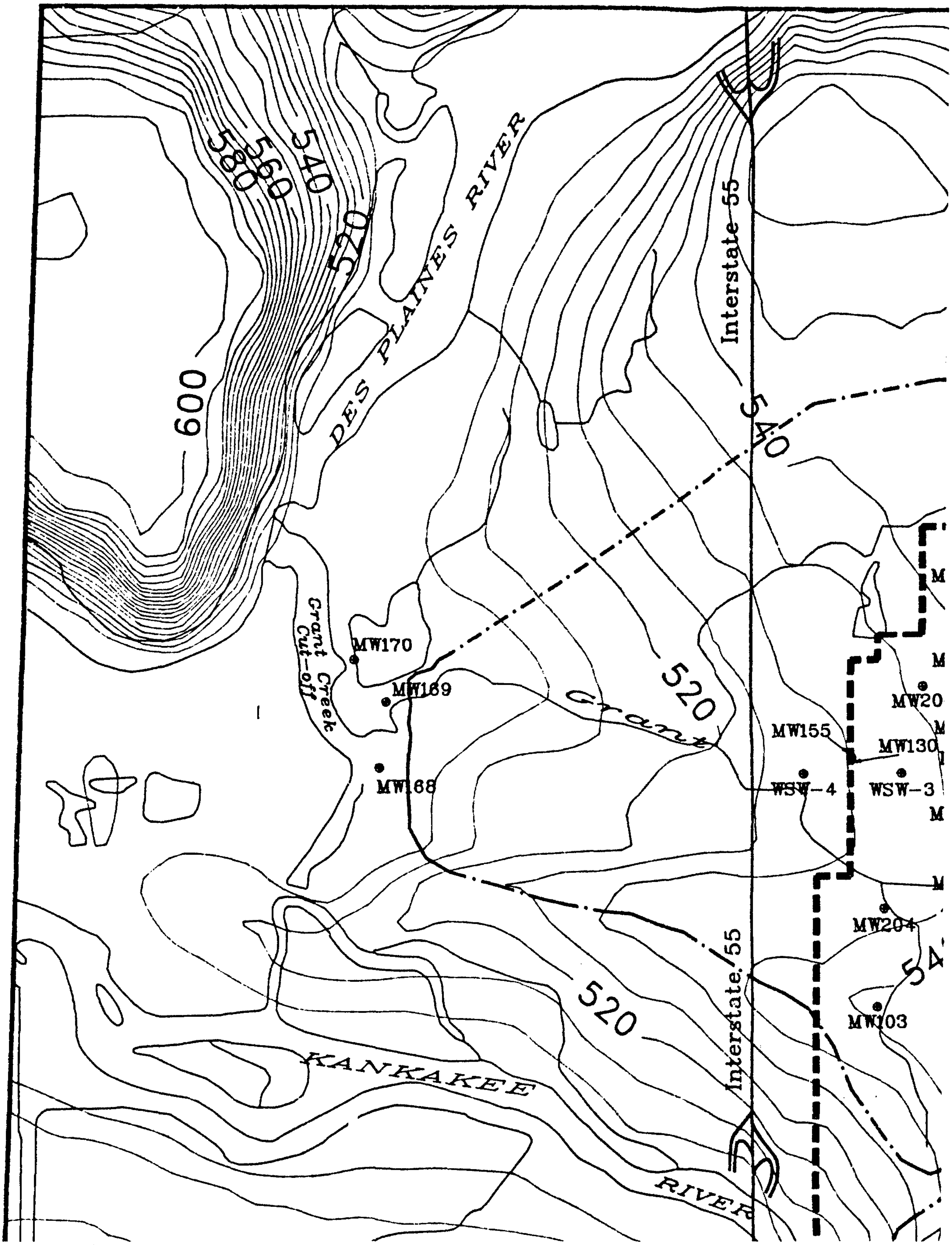
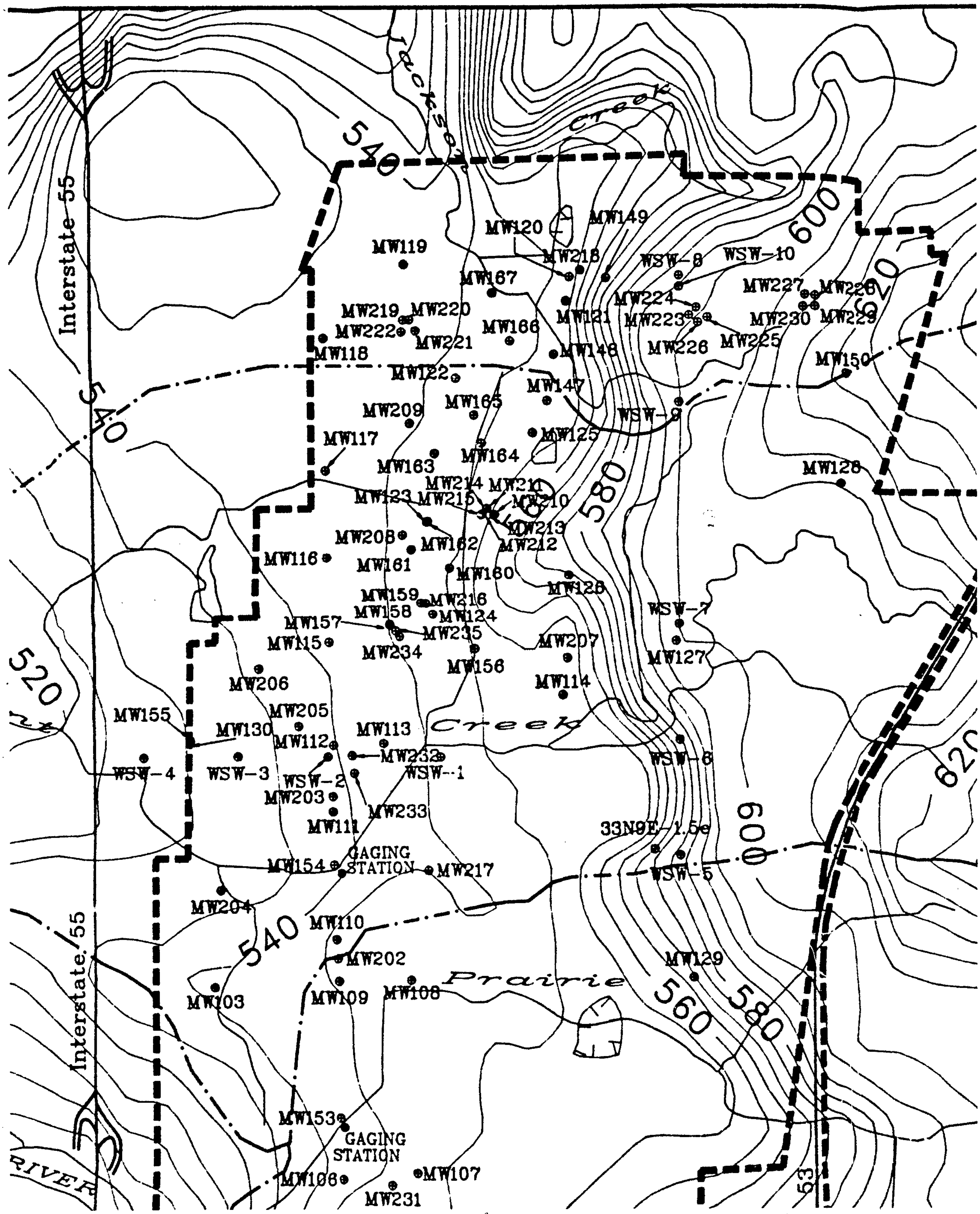


PLATE 1

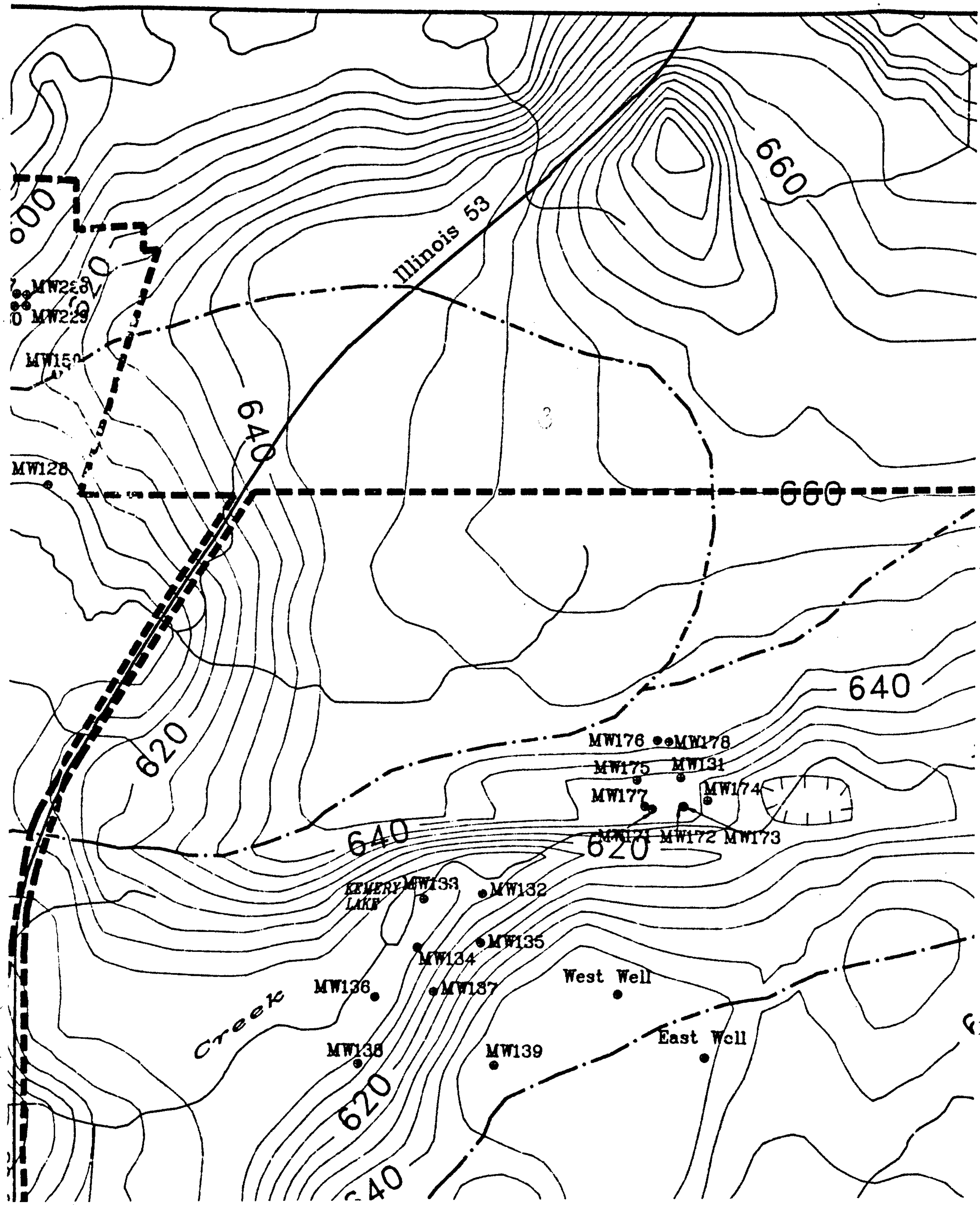
Monitoring Well Locations
at
Joliet Army Ammunition Plant



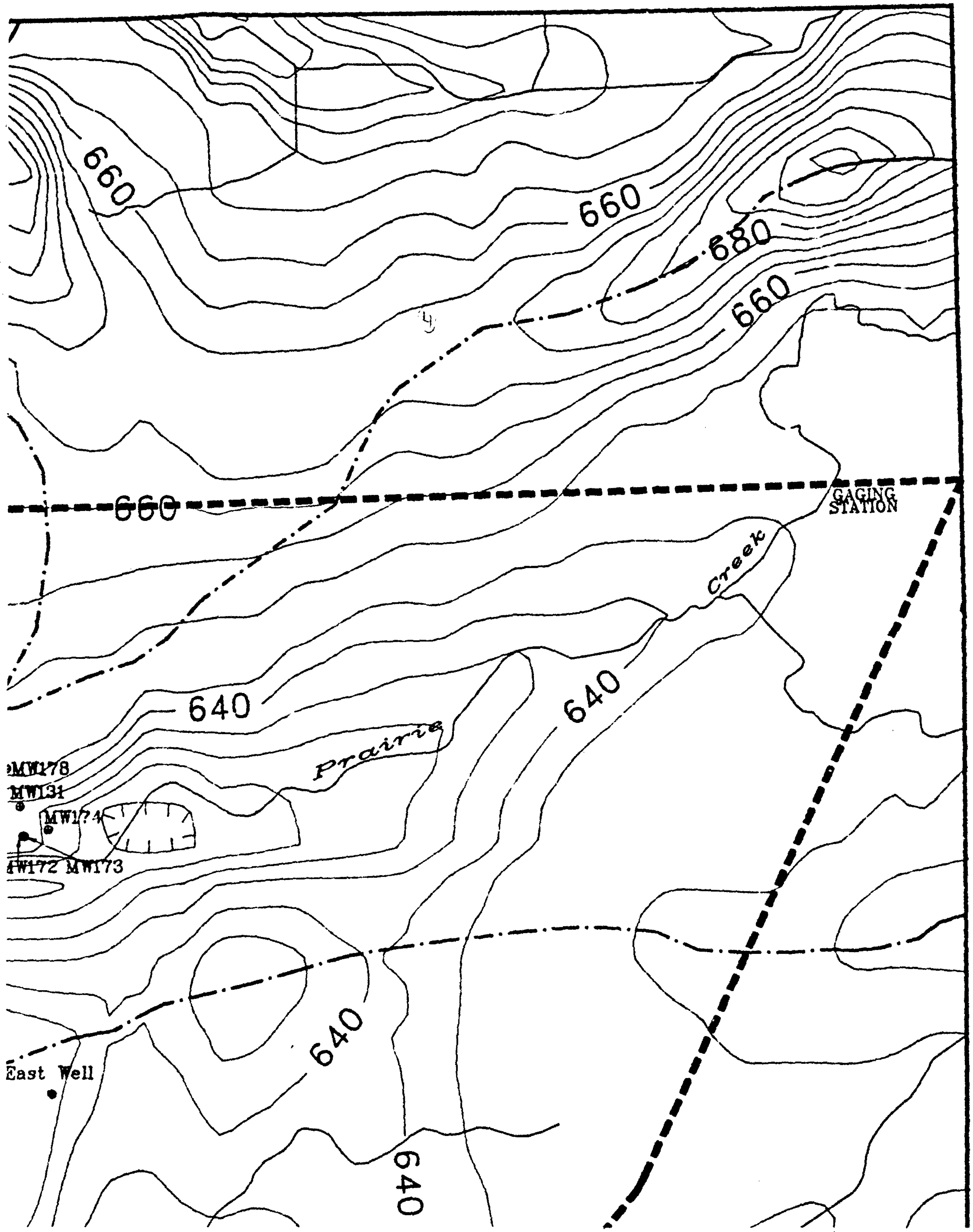
600
580
560
540
520
DES PLAINES RIVER
Interstate 55
540
Grant Creek Cut-off
MW170
MW169
MW168
Grant
520
MW155
MW130
WSW-4
WSW-3
MW20
MW204
MW103
520
Interstate 55
KANKAKEE
RIVER



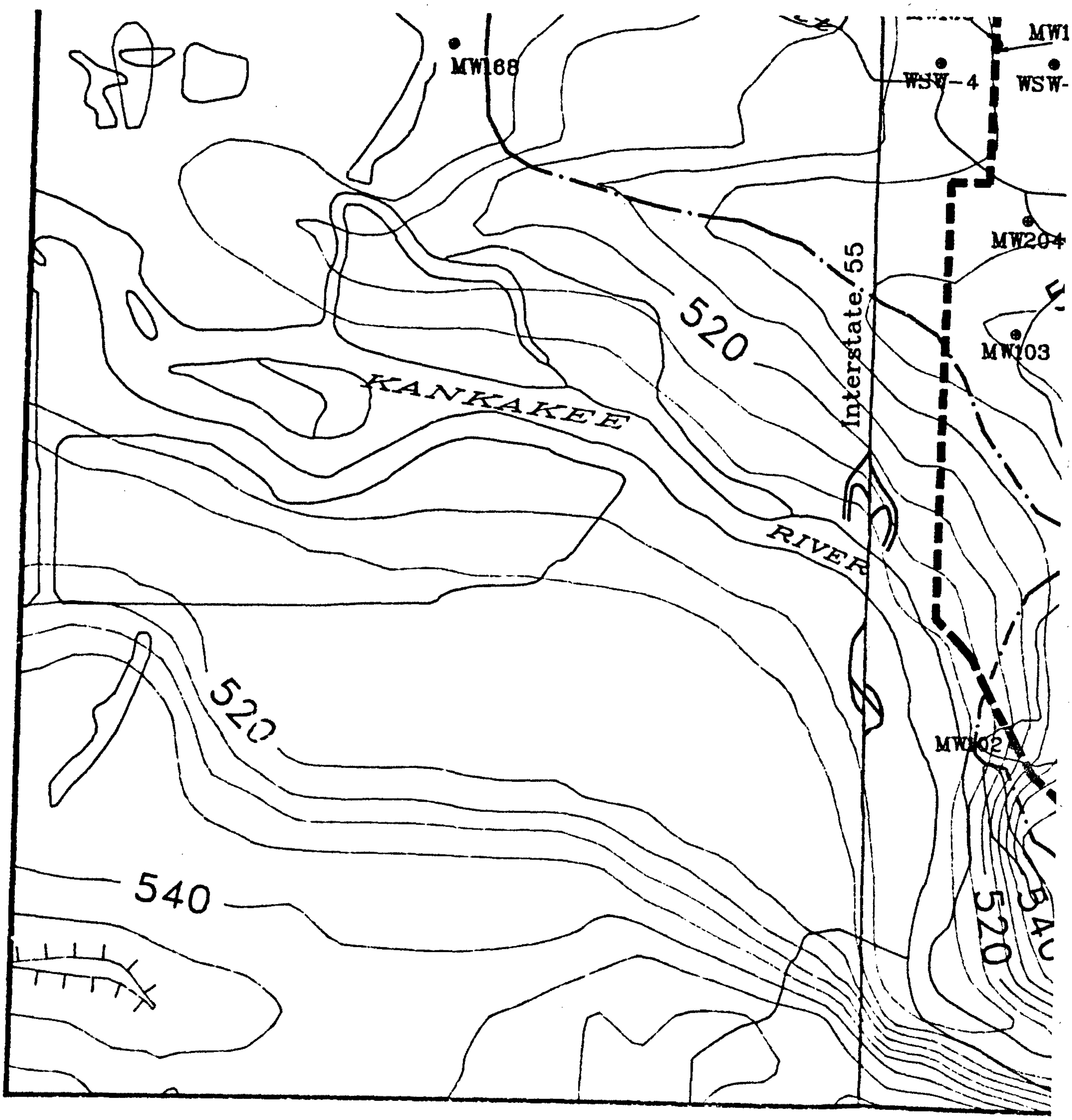
Interstate 55
Jackson Creek
540
600
620
580
560
520
MW119
MW120
MW149
MW218
WSW-8
WSW-10
MW167
MW227
MW228
MW224
MW219
MW220
MW121
MW223
MW230
MW229
MW222
MW221
MW166
MW118
MW148
MW226
MW225
MW122
MW150
MW147
MW209
MW165
WSW-9
MW117
MW125
MW163
MW164
MW128
MW214
MW211
MW123
MW215
MW210
MW208
MW213
MW162
MW212
MW116
MW161
MW160
MW126
MW159
MW216
MW158
MW124
WSW-7
MW157
MW235
MW115
MW207
MW234
MW127
MW156
MW206
MW114
MW155
MW205
MW130
MW113
Creek
MW112
MW232
WSW-6
WSW-4
WSW-3
WSW-2
WSW-1
MW203
MW233
MW111
33N9E-1.5
GAGING STATION
MW154
MW217
WSW-5
MW204
MW110
MW202
MW129
Prairie
MW103
MW109
MW108
MW153
GAGING STATION
MW107
MW106
MW231
RIVER
53



Illinois 53
660
MW228
MW229
MW150
640
MW128
660
640
620
MW176
MW178
MW175
MW131
MW177
MW174
640
MW171
MW172
MW173
620
MW133
MW132
LAKE
MW135
MW134
West Well
MW136
MW137
Creek
East Well
MW138
MW139
620
640



660
660
680
660
660
GAGING
STATION
Creek
640
640
Prairie
MW178
MW131
MW174
MW172 MW173
640
East Well
640



LEGEND

5

Facility Boundary

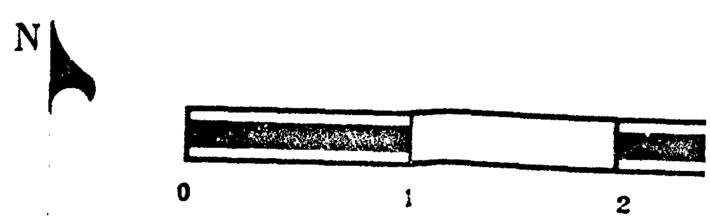
Surface Water Divide

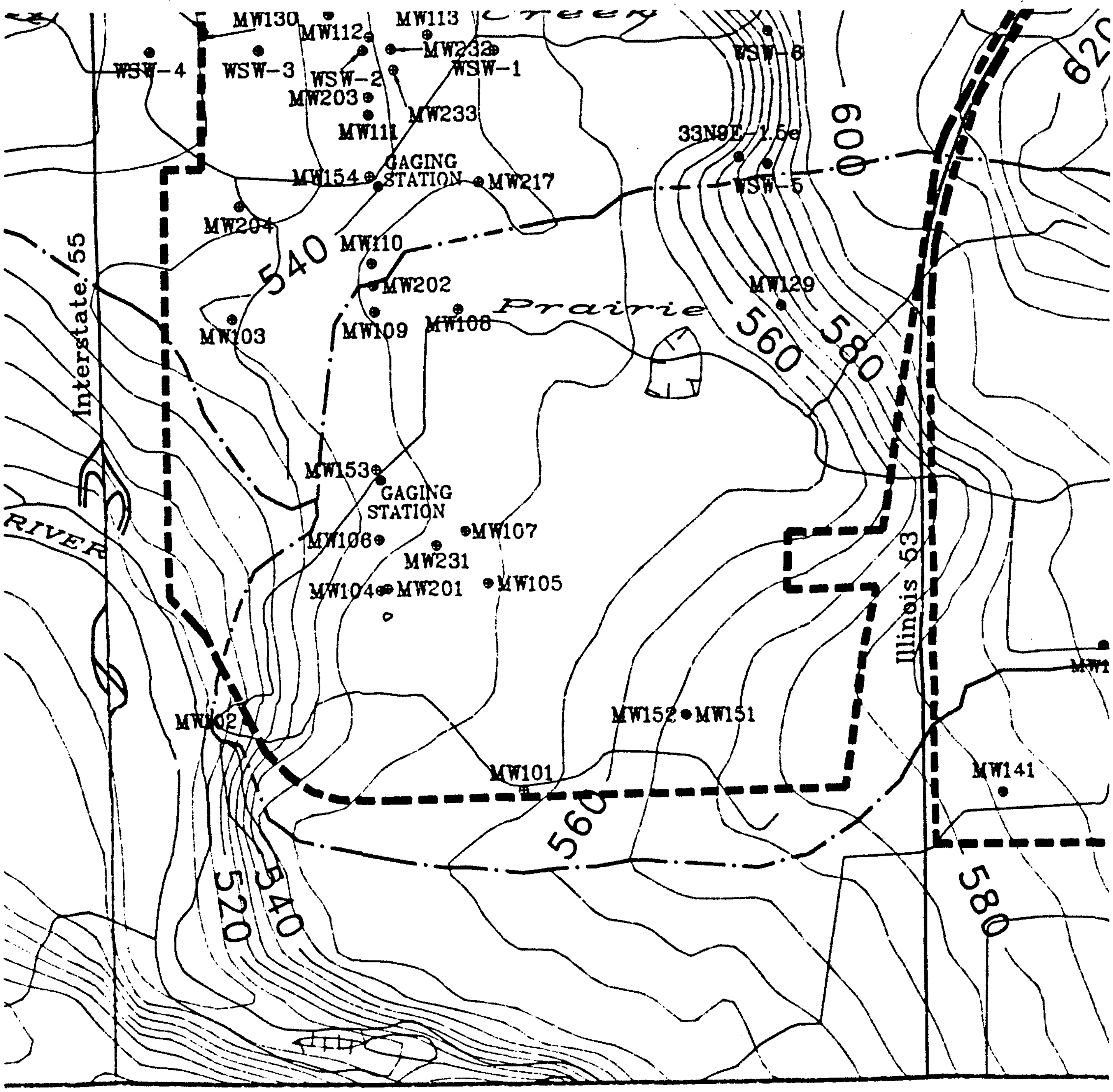
Divided Highway

MW101 Monitoring Well

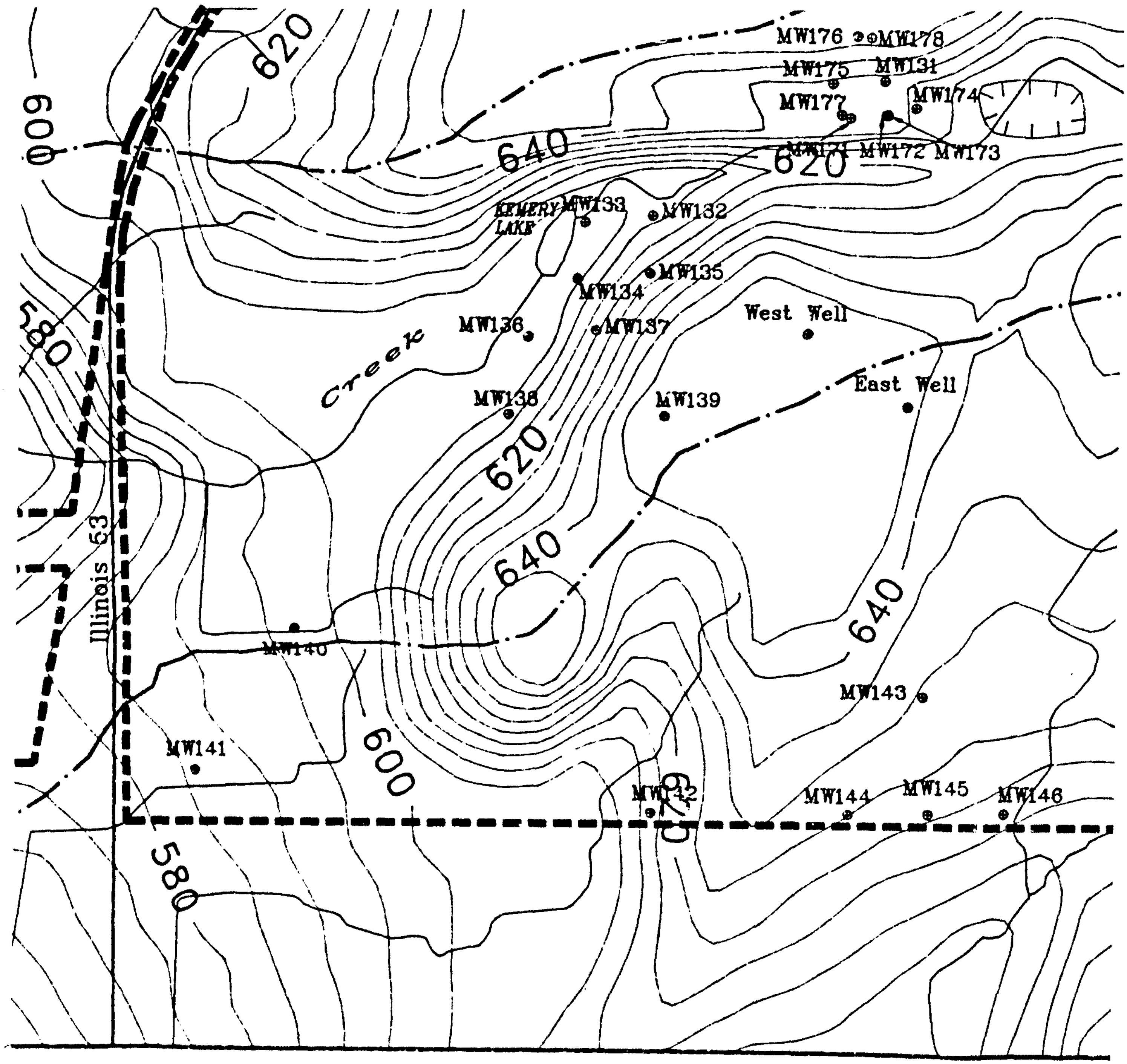
Surface Water

540 Topographic Elevation, feet above mean sea level





1 2 3 Kilometers


MW176
MW178
MW175
MW131
MW177
MW174
MW171
MW172
MW173
640
620
600
KEMERY LAKE
MW133
MW132
MW134
MW135
MW136
MW137
West Well
Creek
580
MW138
MW139
East Well
620
640
Illinois 53
MW140
640
MW143
MW141
600
MW142
MW144
MW145
MW146
580

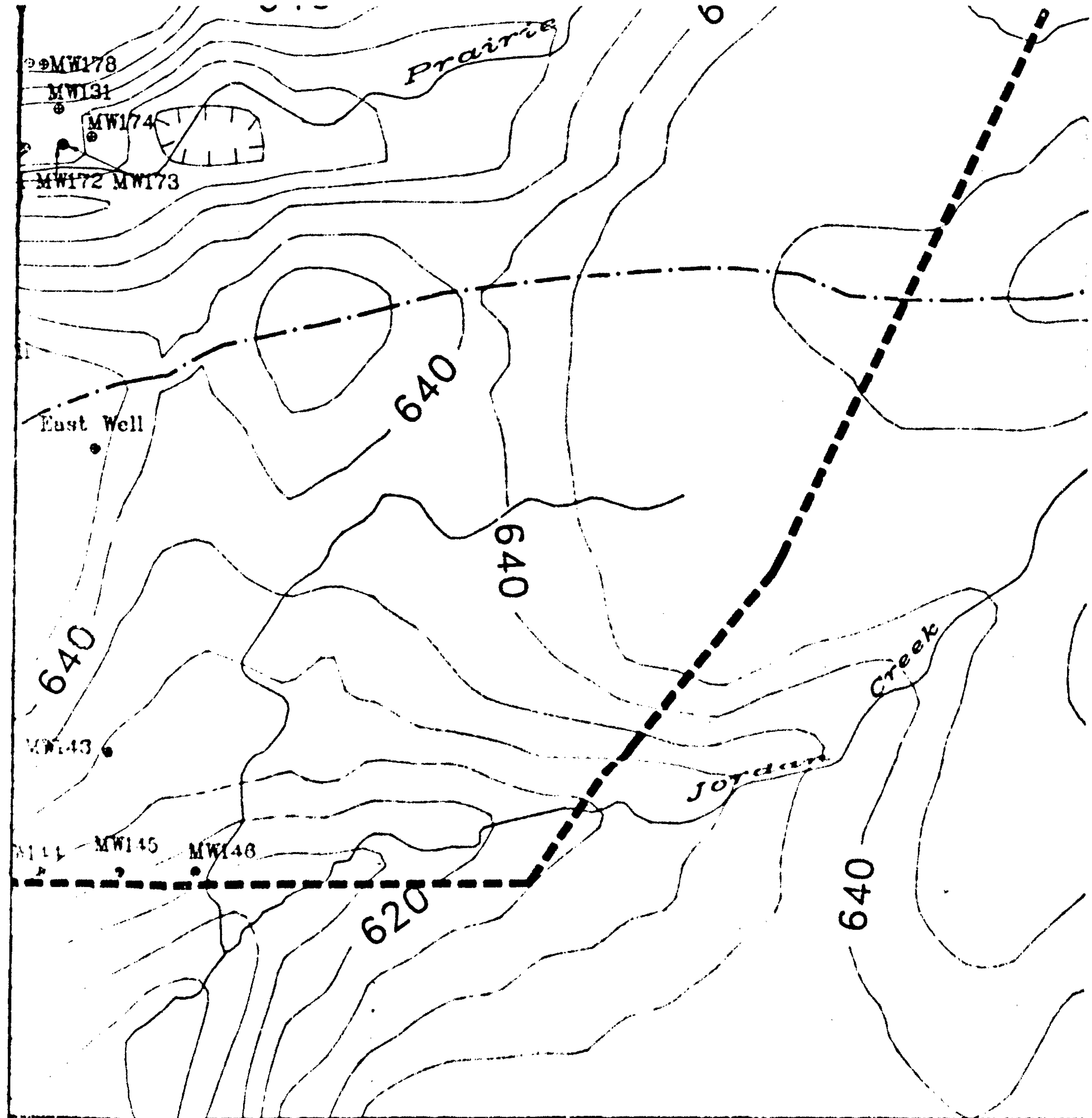


PLATE 2

Topography and
Hydrologic Basins at
Joliet Army Ammunition Plant